SELF-LIGATING vs CONVENTIONAL TWIN BRACKETS DURING EN-MASSE SPACE CLOSURE WITH FRICTIONLESS MECHANICS

Dissertation submitted to

THE TAMILNADU DR. M.G.R.MEDICAL UNIVERSITY

In partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH V

ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS

APRIL - 2012

CERTIFICATE

This is to certify that this dissertation titled **"SELF-LIGATING vs CONVENTIONAL TWIN BRACKETS DURING EN-MASSE SPACE CLOSURE WITH FRICTIONLESS MECHANICS"** is a bonafide record of work done by **DR.V.SARAVANAN** under my guidance during his postgraduate study period between 2009–2012.

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, in partial fulfillment for the degree of **Master of Dental Surgery** in Branch V – Orthodontics and Dentofacial Orthopedics.

It has not been submitted (partially or fully) for the award of any other degree or diploma.

RAGAS DENTAL COLLEGE & HOSPITAL CHENNAI

H. O. D & Guide

N.R. [signature] 24/12/11

Dr. N.R. Krishnaswamy M.D.S.,
M.Ortho R.C.S. (Edin
Dip N.B. (Ortho)
Professor& Head
Department of Orthodontics
Ragas Dental College and Hospital
Chennai.

Dr. N. R. KRISHNASWAMY.
PROFESSOR & HEAD
Dept. of Orthodontics
RAGAS DENTAL COLLEGE & HOSPITAL
2/102. East Coast Road
Uthandi, Chennai-600 119

Principal

[signature]

Dr. S. Ramachandran M.D.S.,
Ragas Dental College & Hospital
Chennai

PRINCIPAL
RAGAS DENTAL COLLEGE & HOSPITAL
CHENNAI

Acknowledgement

It is a pleasure to express my gratitude to all, who have enlightened me and helped me through the completion of this thesis.

*I am indebted to my respected and beloved professor and guide, **Dr. N.R. KRISHNASWAMY,** M.D.S., M.Ortho RCS. (Edin), Diplomat of Indian board of Orthodontics, Professor and Head, Department of Orthodontics, Ragas Dental College and Hospital, Chennai. He has always been a great source of inspiration and I am grateful to him for his most valuable guidance and support. It is quite an honor to study under such an icon and no student can ask for more. I am very thankful to him for taking time from his busy schedule many a times to share his wisdom and experience.*

*My sincere thanks to my Professors **Dr. S. VENKATESWARAN,**M.D.S. & **Dr. ASHWIN GEORGE**, M.D.S, for their constant source of encouragement and invaluable suggestions which has helped me see through my thesis with ease. I want to take this opportunity to acknowledge and thank them for their support throughout my post graduation.*

*I am grateful and sincerely thankful to **Dr. REKHA BHARADWAJ**, M.D.S, (Reader), for his vehement personal interest, wise counsel and never ending willingness to render generous help to me in carrying out this work from its inception to its consummation.*

*My sincere thanks to Professor **A.KANAKARAJ** Chairman & **Dr. S.RAMACHANDRAN,** Principal, Ragas Dental College & Hospital for providing me with an opportunity to utilize the facilities available in this institution in order to conduct this study.*

I greatly acknowledge ***Dr. SHAHUL****(Associate Professor),* ***Dr. ANAND*** *(Reader)* ***Dr. JAYAKUMAR*** *(Reader),* ***, Dr. SHAKEEL****(Reader),* ***Dr. RAJAN , Dr. SHOBANA, Dr. PRABHU , and Dr.BIJU TOM*** *for their support, enthusiasm & professional assistance throughout my post graduate course.*

My heartfelt thanks to my wonderful batch mates, ***Dr.Ashwin.V.T, Dr.Ayush, Dr.Mahalaxmi, Dr.Sabitha, Dr.Sreesan, Dr.Vinod,*** *and* ***Dr.Sheel*** *who were cheerfully available at all times to help me. I wish them a successful career ahead.*

I also extend my gratitude to my juniors ***Dr. Ashwin, Dr. Manikandan, Dr. Deepak, Dr. Siva Subramanian, Dr. Sakthi, Dr. Aarthi , Dr. Ravanth, Dr.Femin, Dr.Murali, Dr.Vishal, Dr.Gayathri , Dr.Manali, Dr.Vikram, Dr.Regina and Dr.Saptharishi*** *for all their support and for cooperating with me to conduct this study on their patients.*

I thank ***Mr.Porselvan*** *, for helping me with the statistical analysis for the study.*

My thanks to ***Mr. Ashok,*** *and* ***Mr. Rajendran & Mr.Kamaraj*** *for helping me with the technical work and the photographs for the study.*

I would like to thank ***Sisters Lakshmi, Rathi , Kanaka,& Azeena, Ms. Banupriya,, Ms.Divya. and attender Mr. Baskar, Mr. Mani*** *for their co-operation and help during my post-graduate course.*

*Words cannot express my gratitude to **MY PARENTS** who have showered their love, blessings, understanding and support and borne many sacrifices to make me who I am today. I would like to dedicate this work to my parents, who encouraged me to pursue my career in dentistry.*

*I also thank **My Brother** for his constant love, support and encouragement.*

CONTENTS

INTRODUCTION

The systematic evolution of dental materials has led to a constant pursuit of technological innovations in orthodontics. Appliance biocompatibility, treatment efficiency and patient convenience are the major confronting factors in success of orthodontic treatment.[36]

First premolar extraction treatment, which is a regular extraction pattern to correct severe crowding, excessive over jet, and bimaxillary protrusion, requires maximum retraction of anterior teeth to achieve desirable results. For minimizing anchorage loss and maximizing tooth movement efficiency, **Tweed**[60,61] emphasized anchorage preparation as the first step in orthodontic treatment. **Storey and Smith**[52] advocated the use of light forces, and **Begg**[6] emphasized the advantages of differential force to produce the maximum rate of movement of teeth.

Conventionally, one of the popular methods of space closure is sliding mechanics. In this technique, one of the alternatives to en-masse space closure is the retraction of canines prior to incisor retraction. However, sliding produces friction at the bracket-wire-ligature interface, which in turn affects the rate of tooth movement.[36]

There have been controversies as to how to maximize anchorage preservation in first premolar extraction cases. **Proffit and Fields**[37] recommended separate canine retraction for maximum anchorage, stating that this approach would allow the reaction force to be constantly dissipated over the large periodontal ligament area in the anchor unit. They acknowledged, however, that closing the space in two steps rather than in one would take nearly twice as long. **Roth**[48] also recommended separate canine retraction for maximum anchorage extraction cases but did not recommend it for moderate ones**. Kuhlberg**[29] described separate canine retraction as less taxing on anchorage because the two canines are opposed by several posterior teeth in the anchor unit. On the other hand, **Staggers and Germane**[51] described anchorage as being taxed twice with a two-step retraction, as opposed to once with en- masse retraction, pointing out that the posterior segment is unaware of knowing how many teeth are being retracted and merely responds according to the force system involved**. Burstone**[9] also questioned whether anchorage is better controlled with separate canine retraction.

Therefore, an alternate approach to overcome friction is loop mechanics (frictionless mechanics). The loop incorporated in the retraction wire brings about the desired space closure with optimum force, active for a longer duration of time and eliminates friction. Different loop designs and its biomechanical consideration have been discussed in previous literature studies.

Double key-hole loop, introduced by **John Parker**[47] has the following specific advantages.

1. Allows the operator the luxury of complete space closure with one set of arch wire.
2. Allows a reasonably happy medium between severe tipping and sliding mechanics.
3. Allows the operator to select how the space will be closed depending on anchorage considerations.

4. Good control of canine rotation during space closure.

There are numerous studies reporting the efficiency of retraction with loop mechanics that has been done using conventionally ligated bracket system.

Recently, reports claim that low friction self -ligation brackets coupled with light forces enhance the rate of tooth movement with decreased treatment time, decreased appointment time, improved oral hygiene, increased patient acceptance and superior results[8]. These brackets were introduced by **Dr. Jacob Stolzenberg.**[22] They had a mechanical device built into the bracket to close off the edgewise slot. They are generally smoother for the patients because of the absence of wire ligature. The precision arm or the sliding fourth wall accurately locks the archwire within the dimensions of the slot providing robust ligation and controlled tooth movement.

Self-ligating brackets are broadly classified into Active, Passive and Interactive self-ligating brackets. Active brackets, with the labial fourth wall consist of a spring clip in contact with the arch wire. These brackets express greater torque control. In the active self-ligating system, friction is produced as a result of the clip pressing against the archwire.[20] In passive self-ligating brackets, the slot is transformed into a tube by means of a labial "fourth wall" that does not contact the archwire. The full expression of bracket properties is achieved only when higher dimensional wires are used.[20] In interactive brackets clip is passive with the initial arch wire. As the dimension of the wire increases the clip actively engage the arch wire and express greater torque control, which is required in the retraction and finishing stages of treatment.[9]

Several, in vitro studies comparing the frictional resistance of self-ligating brackets have shown lower friction compared to conventionally ligated brackets. Self-ligation brackets maintain lower friction when coupled with small archwires.[19,62,63] Friction increased as the arch wire size increased.[4,53] However, extrapolation of in-vitro studies has to be cautioned in vivo because it is difficult to simulate the clinical conditions due to variables like masticatory forces and oral function, different malocclusion, width and compressibility of PDL, tooth rotation, torque at the wire-bracket interface, bracket/archwire angulation, and temperature and moisture.[41,42]

Very few articles describe the retraction efficiency of self-ligating brackets. It has been found that there is no significant difference between self-ligating and conventional brackets. However, all these studies were based on sliding mechanics and passive self-ligating brackets. Literature is scant with regard to the use of interactive self-ligating bracket systems for space closure. Moreover, there has been no study done previously evaluating the efficiency of double key-hole loop retraction mechanics.

To the best of our knowledge, no previous in-vivo studies have compared the efficiency of retraction with double key-hole loop mechanics (frictionless mechanics) between conventional and self- ligating bracket.

Thus, the purpose of this study was to compare the efficiency of en-masse retraction with double key-hole loop between conventional straight wire bracket and Interactive self-ligating bracket.

REVIEW OF LITERATURE

Jacob Stolzenberg (1935)[22] First introduced self-ligating bracket and described the features of the Russell Lock edgewise attachment, they are generally smoother for the patients because of the absence of wire ligature. The precision arm or the sliding fourth wall accurately locks the archwire within the dimensions of the slot providing robust ligation and controlled tooth movement.

Tweed (1943)[60] in his philosophy of orthodontic treatment documented the main aim is to preserve the anchorage, right from beginning of the treatment and to prevent the major reciprocal reaction that occurs towards the retraction stages of the treatment.

Burstone.C.J and Herbert.A (1976)[8] discussed the disadvantages of sliding mechanics and described the alternate method of space closure the frictionless mechanics based upon incorporation of loop (a spring). There are three primary characteristics that describes a retraction spring

1. The moment –to-force ratio (M/f) which determines the center of rotation of the tooth during its movement.
2. The force at yield; this represents the greatest force that can be delivered from a retraction spring without permanent deformation
3. Force-to-deflection rate and /or moment-to-rotation rate.

Although the three primary characteristics define the force properties of a retraction spring, it should be noted, that, with large activations, M/F ratio and F/A rate may change somewhat as a result of the altered shape of the spring; nevertheless, these characteristics are useful in defining the mechanical properties of a retraction spring. The most important characteristic of a retraction spring is moment-to-force ratio, since it is this ratio that determines the position to which the tooth will move (that is, whether the tooth will translate or tip). Any activation over 1.4 mm. would produce permanent deformation of the spring. Since common activations of avertical loop are approximately 1 mm. The force at yield is2,207 Gm.; the deflection at yield, 1.1 mm.; thus, 1 mm. activation would deliver 2,099 Gm. Forces of this magnitude are clearly excessive, regardless of the centerof rotation required for a canine or anterior tooth retraction.

Rakosi Thomas (1982)[46] defined various reference plane used for analysis. The techniques to construct this plane and how to make measurements were clearly described.

Roth. H. Ronald (1991)[47] discussed about double key hole loop retraction wire in the chapter treatment mechanics for the straight wire appliance. Double key-hole loop, introduced by **John Parker** has the following specific advantages.

1. Allows the operator the luxury of complete space closure with one set of arch wire.

2. Allows a reasonably happy medium between severe tipping and sliding mechanics.

3. Allows the operator to select how the space will be closed depending on anchorage considerations.

4. Good control of canine rotation during space closure.

Staggers .A.J, Germane. N (1991)[51] Described the importance of gable bend in the retraction mechanics. site of gable bend placement and the degree of gable bend is main governing factor in different anchorage pattern. In group A anchorage consideration the gable bend is placed distal to the loop and increasing the moment in the posterior segment, which is helpful in anchorage preservation. He also quoted that anchorage as being taxed twice with a two-step retraction, as opposed to once with en masse retraction, pointing out that the posterior segment is unaware of knowing how many teeth are being retracted and merely responds according to the force system involved**.**

Kemp et al (1992)[26] compared the frictional forces between self-ligating and conventional edgewise brackets with different archwire size, archwire alloy or second order angulations. A testing apparatus was constructed to stimulate the clinical situation in which a maxillary canine is retracted through a first pre-molar extraction space along a continuous archwire, with sliding mechanics. The results demonstrated that at 0* and 10* angulation, self-ligating brackets demonstrated lower levels of friction. Round archwires in smaller sizes produced smaller friction.

Roth. H. Ronald (1994)[48] in his treatment mechanics for straight wire appliance. He discussed the anchorage consideration and treatment mechanics for various extraction pattern. He strongly recommended individual canine retraction for maximum anchorage cases but did not recommend it for moderate anchorage situation.

Shivapuja et al(1994)[57] in their comparative study on the effect of self-ligating bracket and brackets with conventional ligation system observed that self-ligating bracket systems displayed a significantly lower level of frictional resistance,less chair side time and improved infection control compared to metal or ceramic brackets.

Tselepis M, Brockhurst P, West VC (1994)[66] compared the dynamic frictional resistance between orthodontic brackets and arch wires, arch wire material, bracket material, bracket-to-arch wire angulation, and lubrication (artificial saliva). The frictional force involved in sliding a ligated arch wire through a bracket slot was measured with a universal testing machine. Of the four factors investigated, all were found to have a significant influence on friction. Polycarbonate brackets showed the highest friction and stainless steel brackets the lowest. Friction increased with bracket-to-arch wire angulation. Lubrication significantly reduced friction. A range of 0.9 to 6.8 N frictional forces was recorded. The actual force values recorded were most useful for comparing the relative influence of the factors tested on friction, rather than as a quantitative assessment of friction in vivo. The forces observed suggest that friction may be a significant influence on the amount of applied force required to move a tooth in the mouth. Hence, arch wire and bracket selection may be an important consideration when posterior anchorage is critical.

Jacobson.A. Caufield .W. Page (1995)[23] defined various landmarks used in cephalometry. Stepwise identification of landmarks, described the importance of natural head posture, it is a standardized and reproducible orientation of the head in space when one is focusing on a distance point at eye level. This standardized orientation of head posture reduces the error in various cephalometric assessments.

Warita.H. et al (1996)[69] compared the application of alight continuous force(5g/f) vs a light, dissipating force (10g/f) for 39 days on rat molars. He found 1.8 times greater tooth movement with the light, continuous force. “histological observation showed that the Pdl applied with light continuous force tended to be more physiologically preserved than that applied with light dissipating force.

G.E. Read Ward et al (1997)[16] compared the static frictional resistance of three self-ligating brackets with a conventional steel ligated Ultra–trim bracket. The effects of archwire size, bracket- archwire angulation and the presence of unstimulated human saliva were investigated. The study demonstrated that both increase in wire size and bracket-arch wire angulation resulted in increased static frictional resistance for all bracket types tested, but self -ligating brackets showed reduced frictional resistance in comparison to steel ligated brackets only under certain conditions.

Dwight H Damon (1998)[11] compared the friction produced by three types of conventional twin brackets with three self-ligating brackets. When 0.019x0.025 stainless steel wires were drawn through the bracket, a Conventional twin ligated with elastic modules produced 388 to 609 times the friction of passive self -ligating brackets. Conventional twins with metal ligatures were found to have friction values, more than 300 times those of passive self-ligating brackets. The active self-ligating bracket produced 216 times the friction of a passive self-ligating bracket.

Luca Pizzoni et al (1998)[30] studied the frictional resistance encountered in two self- ligating (Speed, Damon SL) and two conventional brackets (Dentauram). These brackets were tested with four wires (Stainless steel, Beta-titanium - round and rectangular). The result showed that round wires had a lower friction than rectangular wires. Beta-titanium wires had higher friction than stainless steel. The self -ligating brackets had a markedly lower friction than conventional brackets at all angulations. It was concluded that the selection of bracket design, wire material and wire - cross section significantly influences the forces acting in a continuous arch system.

Kapur et al (1998)[25] conducted a study to compare the kinetic frictional force of a new self-ligating bracket (Damon SL) with that of a conventional twin bracket. The results revealed that the self-ligating brackets had lower kinetic coefficient of friction. They concluded that self-ligating brackets could offer a substantial clinical advantage to orthodontists employing sliding mechanics.

Susan thomas and Martyn Sheriff (1998)[53] done a study to compare the frictional characteristics of two types of self-ligating brackets(Damon and Time) and two types of pre-adjusted edgewise brackets(Tip-Edge and 'A'company). The test brackets were glued to steel bars and aligned using a preformed jig. Five combinations of archwire size and material were used(0.014-inch NiTi, 0.0175-inch multistrand SS, 0.016×0.022-inch NiTi, 0.016×0.022-inch SS and 0.019×0.025-inch SS wires). Author found that Damon bracket produced the least frictional resistance followed by Time bracket and conventional brackets. The 0.019×0.025-inch stainless steel produced maximum friction.

Kusy,whitley (1999)[28] reported that there is every indication that classical friction controls sliding mechanics below some critical contact angle. Once that angle is exceeded, however, binding and notching phenomena increasingly restrict sliding mechanics. Thus, knowledge of the archwire or bracket alone is insufficient; knowledge of the archwire-bracket combination is necessary for contact angle to be calculated. So they defined resistance to sliding as a combination of three components: friction, binding and notching.

Profit and Fields (2000)[37] discussed the methods to control anchorage. The extent to which anchorage should be reinforced depends on the tooth movement that is desired. For significant differential tooth movement, the ratio of periodontal ligament area in the anchorage unit to periodontal ligament area in the tooth movement unit should be atleast 2 to 1 without friction, 4 to 1 with friction. Anything less produces something close to reciprocal movement. A common way to improve the anchorage control is to pit the resistance of a group of teeth against the movement of a single tooth, rather than dividing the arch into more or less equal segments. For all four extraction cases with maximum anchorage consideration (60%anterior retraction and 40%posterior forward movement) the three possible approaches for space closure are (1) one step space closure with friction less appliance (2) a two-step closure sliding the canine along the arch wire, then retracting the incisors (as in the original Tweed technique) (3) two step space closure, tipping the anterior segment with some friction, then uprighting the tipped teeth (as in the beg technique)

It would be perfectly possible to reduce the strain on posterior anchorage by retracting the canine individually, pitting its distal movement against mesial movement of all other teeth with in the arch. After the canine tooth had been retracted, one could then add it to the posterior anchorage unit and retract the incisors. This approach would have the advantage that the reaction force would always be dissipated over a large periodontal ligament area in the anchor unit. Its disadvantage is that closing the space in two steps rather than one would take nearly twice as long. So the treatment time is therefore increased.

kuhlberg.J.K,Priebe .N.D (2001)[29] reviewed angle's 5 types of anchorage control. Occipital anchorage depended on the use of extraoral headgear. Intermaxillary anchorage included the use of elastics. The 3 remaining methods were dental anchorage techniques. Angle described simple, reciprocal, and stationary methods for dental anchorage. Both simple and reciprocal anchorage methods relied on competing support of the dentition to effect tooth displacement. In contrast, Angle's stationary anchorage methods were based on his view that firm support of the anchorage units, through handling multiple teeth, acted to resist tipping and thus promote anchorage. He described separate canine retraction as less taxing on anchorage because the two canines are opposed by several posterior teeth in the anchor unit.

McLaughin, Bennet and Trevisi (2001)[32]discussed about the play of the archwire placed in bracket slot. When an undersized wire placed in 0.022 slot that is using 19×25inch wire as the final larger dimension wire there will be slop or play of 10° between the bracket slot and archwire.

Thorstenson GA, kusy (2001)[62] studied the frictional properties of conventional stainless steel brackets that were coupled with rectangular stainless steel archwires and ligated with stainless steel ligature wires and the frictional properties of closed self-ligating brackets coupled with the same archwires were compared in terms of second-order angulation. The slides of these self-ligating brackets passively restrained the archwires within the slots. As a control, the frictional properties of the opened self-ligating brackets, which were ligated with stainless steel ligature wires, were measured. The resistance to sliding of the conventional brackets and the opened self-ligating brackets were measured at ligation forces ranging from 200 to 600 cN and at angles from –9° to 9°. The resistances to sliding of the closed self-ligating brackets were measured at the same angles, but no external ligation forces were applied. In the passive configuration, the conventional brackets exhibited similar frictional resistance as the opened self-ligating brackets, whereas the closed self-ligating brackets exhibited no friction. In the active configuration, all brackets exhibited increased resistance to sliding as the angulation increased. At all angles, the resistances to sliding of the closed self-ligating brackets were lower than those of the conventional brackets because of the absence of a ligation force when the slide restrained the archwire.

Thorstenson et al (2002)[63] investigated the resistance to sliding for 3 self-ligating brackets having passive slides and 3 self-ligating brackets having active clips. (Damon, SPEED, Twinlock, In-ovation, Time, Activa). For each bracket, the resistances to sliding were measured at 14 second order angulations, which ranged from -90 to +90. The results showed that at second order angulations, brackets with active clips that had a low critical angle had more resistance to sliding than did brackets with active clips that had a higher critical angle. Brackets with passive slides that had a high critical angle exhibited the lowest resistance to sliding, but could also do so at the cost of loss of some control.

Darryl V Smith et al (2003)[12] studied the frictional resistance of various bracket archwire combinations. It was concluded that 1) ceramic brackets with and without metal slot had the greatest friction followed by metallic brackets, active self-ligating brackets, variable self-ligating brackets, and passive self-ligating brackets. 2) Stainless steel and braided stainless steel archwires measured greater friction than nickel- titanium. 3) smallerdimension wires had less friction than larger wires, and round wires had less friction than rectangular wires. In addition, consideration of specific bracket - archwire coupling appear to reduce the frictional resistance with sliding.

Edward Mah (2003)[14] conducted frictional study with self-ligating brackets (In-ovation, and Damon 2), and conventional brackets (Mini-twin, Transcend 6000).These 4 brackets were evaluated with 6 different archwires (0.018 NiTi, 0.018 stainless steel, 0.019x0.025 TMA, 0.018x0.025 stainless steel, 0.019x0.025 stainless steel, and 0.021x0.025 stainless steel). Results showed significant differences in dynamics friction among the different bracket types. The Damon 2 brackets produced significantly lesser dynamic friction compared with the In-ovation brackets. In general, the self-ligating brackets produced significantly lesser static, kinetic and dynamic friction than did conventional brackets, and larger diameter archwires produced greater amount of dynamic friction.

Harradine (2003)[18] reported that currently available self-ligating brackets offer the very valuable combination of extremely low friction and secure full bracket engagement and, at last, they deliver most of the potential advantages of this type of bracket. These developments offer the possibility of a significant reduction in average treatment times and also in anchorage requirements, particularly in cases requiring large tooth movements. Whilst further refinements are desirable and further studies essential, current brackets are able to deliver measurable benefit with good robustness and ease of use.

Max Hain et al (2003)[17] did an in-vitro study to examine the friction and stability of the polymeric coated modules with those of other common ligation methods. Six ligation methods (regular uncoated, slick [coated], conventional silver, easy-to-tie, silicone-impregnated, and standard silver modules) were used with standard stainless steel brackets and 0.019 X 0.025-in archwires, and resistance to movement was measured. Two self-ligating (Speed [Strite Industries, Cambridge, Ontario, Canada] and Damon [Sybron Dental Specialities Ormco, Orange, Calif]) brackets were also tested. Results showed the Damon self-ligating brackets produced less friction than the other ligation methods, followed by the coated modules. There was no significant difference between the frictional resistances of brackets ligated with regular uncoated, silicone-impregnated, and easy-to-tie modules. Speed self-ligating brackets produced less friction than regular uncoated, conventional silver, and standard silver modules. The frictional properties of coated modules were not significantly affected by repeating the test 5 times or by storage in saliva for a week. They concluded that Damon brackets produced no recordable friction of ligation. Coated modules produced 50% less friction than all other ligation methods except Damon. The coating was resistant to the simulated effects of the oral environment. Different methods of human saliva application were found to affect the frictional properties of the coating.

Silvia .G, Shpack. N (2003)[54] done a study, to identify various reason for molar anchor loss , it is described as a multifactorial response in relation to the extraction site, appliance type, age, crowding, and overjet. For this study, maximum anchorage cases and had undergone bilateral maxillary premolar extractions, were divided into four groups according to extraction site (first vs second premolars), mechanics (lingual vs labial edgewise appliances), and age (adolescents vs adults). Overjet and crowding were examined from the overall sample. The results showed that as the severity of dental crowding increased, anchor loss is significantly decreased. Labial edgewise appliances demonstrated a significantly greater anchor loss than did lingual edgewise appliances. A greater, though not statistically significant, anchor loss was found in adults than in adolescents. There was a slight nonsignificant increase in anchor loss between maxillary second compared with first premolar extractions.

M.M.Moore, E.Harrington (2004)[33] constructed a jig to measure the frictional forces created by various tip and torque values in association with two types of straightwire bracket and moving along stainless steel (SS) archwires. Steel and cobalt chromium brackets were tested in association with 0.019 × 0.025 and 0.021 × 0.025 inch steel archwires at tips from 0 to 3 degrees and torque values in 2 degree increments from 0 to 6 degrees. Cobalt chromium bracket produced more friction than the stainless steel when used on a 0.021 × 0.025 inch arch at tips of 2 and 3 degrees. This suggests that either the shape or the metallurgy of the chrome cobalt bracket made it more susceptible to binding. Use of 0.021 × 0.025 inch wire produced three times as much friction as 0.019 × 0.025 inch wire, 3.0 N against 1.2 N . Increased tip and torque were associated with highly significant increases in friction ($P < 0.01$). Every degree of tip produced approximately twice as much friction as comparable torque. Authors concluded that space closure should be completed at a 0.019 × 0.025 inch archwire before a 0.021 × 0.025 inch wire is used to complete tooth alignment.

Ravindra nanda (2004)[50] classified various anchorage consideration in extraction treatment cases. They are group A, group B and group C anchorage conditions.

Group A anchorage: This category describes the critical maintenance of the posterior tooth position. Seventy-five percent or more of the extraction space is needed for anterior retraction.

Group B anchorage: this category describes relatively symmetric space closure with equal movement of the posterior and anterior teeth to close the space. This is often the least difficult space closure problem.

Group C anchorage: this category describes “noncritical” anchorage. Seventy-five percent or more of the space closure is achieved through mesial movement of the posterior teeth. This could also be considered to be “critical” anterior anchorage.

Henao SP, Kusy Robert (2005)[19] studied the frictional behaviour of four conventional and four self-ligating brackets that were simulated using a mechanical testing machine. Analysis of the two bracket types were completed by drawing samples of three standardized arch wires through quadrants of typodont models in the dry and wet states as nominal dimension of the arch wire increased, the drawing forces of all brackets increased at different rates. When coupled with a small wire the self-ligating brackets performed better than the conventional brackets. When coupled with larger wires, various designs interchangeably displayed superior performance.

Simona tecco et al (2005)[58] performed an in-vitro study using a specially designed apparatus that included 10 aligned brackets to compare the frictional resistance generated by conventional stainless steel brackets, self-ligating Damon SL II brackets and Time Plus brackets coupled with stainless steel, nickel-titanium and beta-titanium archwires. All brackets had a 0.022-inch slot, and five different sizes of orthodontic wire alloy used. Each bracket-archwire combination was tested 10 times, and each test was performed with a new bracket-wire sample. Results showed -Time Plus self-ligating brackets generated significantly lower friction than both the Damon SL II self-ligating brackets and Victory brackets. However, the analysis of the various bracket-archwire combinations showed that Damon SL II brackets generated significantly lower friction than the other brackets when tested with round wires and significantly higher friction than Time Plus when tested with rectangular archwires. Beta-titanium archwires generated higher frictional resistances than the other archwires. All brackets showed higher frictional forces as the wire size increased. Also these findings suggest that the use of an in vitro testing model that includes 10 brackets can give additional interesting information about the frictional force of the various bracket-archwires combinations to the clinician and the research worker.

Badri .Thiruvenkatachari, A. pavithranand (2006)[3] constructed a jig to differentiate between the right and left molars on the lateral cephalogram, author used a 0.017 x 0.025-in stainless steel wire was shaped in the form of an “L” with 0.5cm of vertical length and 1cm of horizontal length. The horizontal portion was inserted from the mesial side of the buccal tube and cinched behind the tube on the right side. On the left side, the wire was inserted from the distal surface of the buccal tube and cinched mesially.

Miles. P.G et al (2006)[34] compared the effectiveness and comfort of Damon 2 brackets and conventional twin brackets during initial alignment. Comfort on the lips, preferred look, and bracket failure rates were also recorded. The twin bracket was more uncomfortable with the initial archwire. However at 10 weeks, substantially more patients reported discomfort with the Damon 2 bracket when engaging the archwire. Patients preferred the look of the twin bracket over the Damon 2 and more Damon 2 brackets deboned during the study. Author concluded that Damon 2 brackets was no better during initial alignment than a conventional bracket.

Pandis. N, Strigou. S (2006)[38] tested the hypothesis that the engagement mode of wire to bracket affects the buccolingual inclination of maxillary incisors in extraction and non-extraction treatment with self-ligating and conventional brackets. A total of 105 patients followed prospectively, were divided into two groups based on the inclusion of extraction in the treatment planning. These groups were further divided in two subgroups each, one receiving a self-ligating bracket (Damon 2) and the other treated with a conventional (Microarch) Edgewise appliance of the same slot size and prescription. Experimental Variable – Difference in the buccolingual inclination of maxillary incisors before and after treatment with the two appliances across the two treatment groups (extraction and non-extraction) where measured. All patients received a0.019×0.025-inch stainless steel arch wire as a final wire in a 0.022-inch bracket slot showed free play of almost 14°. Authors concluded that Self-ligating brackets seem to be equally efficient in delivering torque to maxillary incisors relative to conventional brackets in extraction and non-extraction cases.

Priscilla Denny (2006)[45] conducted a retrospective study to determine the effects of soldered transpalatal arches (TPA) on the first maxillary molars during orthodontic treatment involving extraction of maxillary first bicuspids. Group A consisted of 20 patients treated with extraction of maxillary first bicuspids and TPAs soldered to the maxillary first molar bands during space closure. Group B received the same treatment without TPAs .This study questioned the effect of a soldered TPA on the anchorage of the maxillary first molars in the horizontal and vertical planes of space. However a soldered TPA might influence the vertical movement of the maxillary incisors. Based on these results the soldered TPA had an intrusive effect on the anterior maxillary incisors.

Daniel J. Rinchusea and Peter G. Miles (2007)[13] elucidated that the ligation force is not transmitted to the tooth but is counteracted by the equal and opposite force of the SL bracket against the archwire . A module exerting 50 g of force pulling the wire into the base of the slot is the load or normal force, so it is pertinent in friction when sliding but does not place a direct force on the tooth. The deflection of the archwire exerts the force on the tooth. Friction, which impedes sliding movements, is determined by multiplying the coefficient of friction of the materials in contact by the normal force, which is the force of ligation. Therefore, friction is directly proportional to the force of ligation. The force applied to the tooth comes from the deflection of the archwire, so, if the module does not deflect the archwire, then it is passive, and no force is applied to the tooth (ligation force only comes in when sliding the wire along the bracket). This normal force is avoided by using a Damon or a SmartClip bracket or "passive" ligation only when the brackets and wire are ideally aligned (so no movement occurs). Any deflection of the archwire that engages the bracket due to rotation, tip, or torque creates a normal force and therefore classical friction. If this deflection is greater, eventually binding and notching occur; these cannot be avoided by any bracket design, SL or conventional.

So a possible ideal SL bracket in future could be a combination bracket with both a spring clip and a passive slide. It could also be tied conventionally. If low resistance to sliding is desired, the passive slide could be used, but, if high resistance to sliding is appropriate, then the active spring clip could be used. For instance, the passive slide to reduce frictional resistance could be used in the initial stages of treatment, and the spring clip later in treatment for 3D control. Therefore, this bracket system could take advantage of an active spring clip or a passive slide at the orthodontist's discretion. Keeping with this idea, the orthodontist could determine the particular needs and vary the type of control for each tooth—spring clip or passive slide, or tied conventionally. It would be a twin bracket with wings that could be differentially tied with a chain elastic. Another possibility could be a hybrid system in which various combinations of conventional brackets and ligation, SL spring clip, and SL passive slide brackets could be integrated into the patient's treatment by using the same slot size for all teeth. For example, in the extraction space-closure method of Gianelly, with crimp-on hooks and molars, the anterior brackets could have conventional brackets and ligation or an SL active clip for 3D control, whereas the posterior teeth could have passive SL brackets to reduce friction for space closure by sliding.

The conventional bracket, spring clip, and passive slide scheme could be modified for extraction and non-extraction patients. Perhaps for certain non-extraction cases, all teeth could have brackets with a spring clip. Depending on the desired movement, SL brackets could be used selectively with conventional brackets. For example, SL brackets could be used only on teeth distal to extraction sites when closing spaces by sliding or distal to open coil springs when opening space.

Turnbull. N.R, David J. Birne, (2007)[64] in their prospective clinical study, authors assessed the relative speed of archwire changes, comparing self-ligating brackets with conventional elastomeric ligation methods, and further assessed this in relation to the stage of orthodontic treatment represented by different wire sizes and types. The time taken to remove and ligate arch wires for 131 consecutive patients treated with either self-ligating or conventional brackets was prospectively assessed. The main outcome measure was the time to remove or place elastomeric ligatures or open/close self-ligating brackets for 2 matched groups of fixed appliance patients: Damon2 self-ligating bracket and a conventional mini-twin bracket. The relative effects of various wire sizes and materials on ligation times were investigated. The study was carried out by 1 operator experienced in the use of self-ligating and conventional brackets. Authors found that Ligation of an arch wire was approximately twice as quick with the self-ligating system. Opening a Damon slide was on average 1 second quicker per bracket than removing elastic from the mini-twin brackets, and closing a slide was 2 seconds faster per bracket. This difference in ligation time between the Damon2 and the conventional mini-twin brackets became more marked for larger wire sizes used in later treatment stages.

Miles.P.G (2007)[35] Compared the rate of en-masse space closure with sliding mechanics between passive self-ligating Smartclip brackets and conventional twin brackets ligated with stainless steel ligatures. 19 patients including 20 arches participated in this prospective trial with 0.018-in slot brackets. All patients had first premolar extractions in atleast one arch and assigned in to two groups in a split-mouth design with sides alternated with each consecutive subject. Space closure was achieved on 0.016 x 0.018-in stainless steel wires with nickel-titanium coil springs activated 6 to 9 mm . The patients were recalled every 5 weeks until 1 side had close. The distance from the mesial aspect of the canine bracket to the distal aspect of the first molar bracket were recored before and after space closure, and average rate of space closure per month was calculated. The median rates of tooth movement for the Smartclip bracket side (1.1mm per month) and the conventional twin bracket side (1.2mm per month). The author found there was no significant difference in the rate of en-masse space closure between the two bracket systems. Self-ligating brackets save time compared to conventional brackets when untying and ligating.

Woo heo and Dong-Seok Nahm etal (2007)[70] compared the amount of anchorage loss of the maxillary posterior teeth and amount of retraction of the maxillary anterior teeth between en-masse retraction and two step retraction that is retraction of the canine by sliding mechanics and retraction of the incisors with loop mechanics in adult class1 women patients. Two groups of 15 patients participated in the study. Lateral cepahalograms taken before and after space closure. Nine skeletal and ten anchorage variables were measured. They concluded that no significant differences in the degree of anchorage loss of the maxillary posterior teeth between the two group. Two-step retraction takes only more time to close the extraction space without advantage of anchorage preservation.

Pandis. N and Argy polychronopoulou (2007)[39] investigated the duration of mandibular-crowding alleviation with self-ligating brackets(Damon 2) compared with conventional appliances(Microarch) and the accompanying dental effects. Fifty-four subjects were selected from a pool of patients. Lateral cephalometric radiographs were used to assess the alteration of mandibular incisor position before and after alignment. He conclude that overall, no difference in the time required to correct mandibular crowding with Damon 2 and conventional brackets was observed because in conventional cases the stress exerted by elastomeric modules and wire ligature adjacent to the bracket sides, precluding free sliding of the wire into the slot walls and adversely affecting movement rate. When the crowding and space in the arch increases there is no difference found between the systems.

Badawi .H.M, Toogood. R. W (2008)[4] done the study to measure the difference in third-order moments that can be delivered by engaging 0.019 x 0.025-inch stainless steel archwires to 2 active self-ligating brackets (In-Ovation, Speed,) and 2 passive self-ligating brackets (Damon2, Calif; Smart Clip). A bracket/wire assembly torsion device was developed. This novel apparatus can apply torsion to the wire while maintaining perfect vertical and horizontal alignment between the wire and the bracket. A multi-axis force/torque transducer was used to measure the moment of the couple (torque), and a digital inclinometer was used measure the torsion angle. Fifty maxillary right central incisor brackets from each of the 4 manufacturers were tested. They concluded that active self-ligating brackets are more effective in torque expression than passive self-ligating brackets.

Badri Thiruvenkatachari, A. pavithranand (2008)[5] To differentiate between the right and left molars on the lateral cephalogram, author used a0.017 x 0.025-in stainless steel wire was shaped in the form of an “L” with 0.5cm of vertical length and 1cm of horizontal length. The horizontal portion was inserted from the mesial side of the buccal tube and cinched behind the tube on the right side. On the left side, the wire was inserted from the distal surface of the buccal tube and cinched mesially.

Heather .L. Zablockl, McNamara. A. james (2008)[21] described that the transpalatal arch (TPA) can be used as an adjunct during orthodontic treatment to help control the movement of the maxillary first molars in 3 dimensions, including producing molar rotation and up-righting, maintaining transverse dimensions posteriorly during treatment, and maintaining leeway spaces during the transition of the dentition. A study was done to test an additional function of the TPA: its ability to enhance orthodontic anchorage during extraction treatment. Records consisting of pre-treatment and post-treatment cephalograms were gathered from several orthodontic practices that used 0.018×0.025-inch pre-angulated appliance. All patients were undergone all first premolar extraction as part of their treatment protocol. Patients were treated either with or without a TPA of the soldered Goshgarian design. They concluded that the usefulness of the TPA for the abovementioned functions is not negated, it does not provide a significant effect on either the anteroposterior or the vertical position of the maxillary first molars during extraction treatment.

Paul Scott and Andrew T.Dibiase (2008)[40] compared the efficiency of mandibular tooth alignment and the clinical effectiveness of a self-ligating and a conventional preadjusted edgewise orthodontic bracket system. It is a multicenter randomized clinical trial. Sixty-two subject with mandibular incisor irregularities of 5 to 12 mm and a prescribed extraction pattern including the mandibular first premolars were randomly allocated to treatment with Damon3 self-ligating or Synthesis conventionally ligated brackets. Fully ligated 0.014-in nickel-titanium archwires were used first in both groups, followed by a sequence of 0.014 x 0.025-in and 0.018 x 0.025-in nickel-titanium, and 0.019 x 0.025-in stainless steel. Study casts were taken at the start of treatment (T1), the first archwire change (T2), and the placement of the final 0.019 _ 0.025-in archwire (T3). Cephalometric lateral skull and long-cone periapical radiographs of the mandibular incisors were taken at T1 and T3. Authors concluded that there is no significant difference was noted in initial rate of alignment for either bracket system. Alignment was associated with an increase in intercanine width, a reduction in arch length, and proclination of the mandibular incisors for both appliances, but the differences were not significant.

Harradine(2008)[20] stated that self-ligating brackets do not require an elastic or wire ligature, but have an inbuilt mechanism that can be opened and closed to secure the arch wire. Author explained the uses of the self-ligating bracket and various designs of self-ligating bracket. The advantages of self-ligating brackets are the full arch wire engagement, reduced friction between the bracket and the arch wire, optimal oral hygiene, less chair side assistance and faster arch wire removal and ligation. Most of the brackets have metal face to the bracket slot that is opened and closed with an instrument or fingertip. The difference between active and passive clip interms alloy of which it is made, the friction and torque which alters the treatment efficiency. In Ovation-R brackets that is reduced bracket width and this narrower width was effective in terms of greater interbracket span. The disadvantages of the bracket system is that difficult in visualise the gingival end of lower arch and made it difficult to open. The lacebacks, underties and elastomerics placed behind the arch wire are competing for space with the bracket clip.

Steven budd, john Daskalogiannakis (2008)[55] investigated to assess and compare the *in vitro* tribological behaviour of four commercially available self-ligating bracket systems. The frictional characteristics of the Damon3, Speed, In-Ovation-R, and Time2 bracket systems were studied using a jig that mimics the three-dimensional movements that occur during sliding mechanics. Each bracket system was tested on the following stainless steel archwires: 0.016 × 0.022, 0.019 × 0.025, 0.020 round, and 0.021 × 0.021 inch Speed D-wire. The crosshead speed was set at a constant rate of 1 mm/minute, and The Damon3 bracket consistently demonstrated the lowest frictional resistance to sliding, while the Speed bracket produced significantly more frictional resistance than the other brackets tested for any given archwire. The self-ligation design (passive versus active) appears to be the primary variable responsible for the frictional resistance generated by self-ligating brackets during translation. Passively ligated brackets produce less frictional resistance; however, this decreased friction may result in decreased 3-dimensional control compared with actively ligated systems.

Tae-kyung kim, ki-Dal Kim (2008)[65] compared the frictional force generated by various combinations of self-ligating bracket types, archwire sizes, and alloy types, and the amount of displacement during the initial leveling phase of orthodontic treatment, by using a custom-designed typodont system. Two passive (Damon 2 and Damon 3), and 3 active SLBs (SPEED, In-Ovation R, Time 2), and SmartClip were tested with 0.014-in and 0.016-in austenitic nickel-titanium and copper-nickel-titanium archwires. To simulate malocclusion status, the maxillary canines were displaced vertically, and the mandibular lateral incisors horizontally from their ideal positions up to 3 mm with 1-mm intervals. Two conventional brackets (Mini-Diamond [MD] and Clarity [CL]) were used as controls. Frictional forces are least in Damon and Innovation brackets in typodont, regardless of archwire size and alloy type. The A-Ni-Ti wire showed significantly lower FF than did the Cu-Ni-Ti wire of the same size. As the amounts of vertical displacement of the maxillary canine and horizontal displacement of the mandibular incisors were increased, frictional force also increased.

Cordasco et al (2009)[10] performed an in vitro study to evaluate the frictional forces between bracket and archwire that included three passive self-ligating brackets (Damon SL). The brackets were individually bonded to a brass mount using a preformed 0.021 x 0.025 inch stainless steel wire jig in order to exclude adverse tipping or torsion. Thirty-six similar set-ups including in total 108 brackets were investigated using the same wire: copper (nickel-titanium) 0.014 inches. A testing machine was designed and constructed to measure the frictional forces between the wire and the three-bracket set-up. The frictional properties of two sets of 12 three-bracket set-ups (control) were tested and measured with an open slide and conventional ligation. A stainless steel ligature wire was used in the former, while elastomeric modules were employed in the latter. They found significant effect of ligation mode on the frictional properties of the three-bracket set-ups. Frictional forces arising from passive self-ligation were significantly lower than those resulting from elastic ligation. The same result was achieved when comparing self-ligation and metallic ligation. No significant difference was found when comparing elastic and metallic ligation.

Krishnan. M. et al (2009)[27] conducted an in-vitro study in which they compared the effects of stainless steel, nickel-titanium, and beta-titanium archwires on frictional forces of passive and active self-ligating brackets with a conventional bracket. All brackets had 0.022-in slots, and the wires were 0.019 x 0.025 in. Friction was evaluated in a simulated half-arch fixed appliance on a Universal testing machine. Results showed that Static and kinetic frictional forces were lower for both the passive and active designs than for the conventional brackets. Maximum values were seen with the beta-titanium archwires, and significant differences were observed between nickel-titanium and stainless steel archwires. With the passive or active self-ligating brackets, stainless steel wire did not produce a significant difference, but differences were significant with nickel-titanium and beta-titanium wires. They concluded that when nickel-titanium and beta-titanium wires are used for guided tooth movement, passive self-ligating bracket appliances can minimize frictional resistance.

Padhraig S.Fleming, Andrew. T. DiBiase (2009)[41] compared the efficiency of mandibular arch alignment in 3 dimensions with a self-ligating bracket system (SmartClip) and a conventional preadjusted edgewise twin bracket (Victory) in nonextraction patients. This was a prospective, randomized, controlled clinical trial. Sixty-six consecutive patients satisfying the inclusion criteria were enrolled in the study. Pretreatment mandibular arch irregularity was measured by using a coordinate measuring machine. A 0.016-in round martensitic active nickel-titanium aligning archwire was placed in all subjects. Mandibular arch irregularity was remeasured

8 weeks later and found that bracket type had little influence on alignment efficiency. Authors concluded that efficiency of alignment in the mandibular arch in nonextraction patients is independent of bracket type. Alignment efficiency is largely influenced by initial irregularity.

Padhraig S.Fleming, Andrew. T. DiBiase (2009)[42] compared the effects of 2 preadjusted appliances on angular and linear changes of the mandibular incisors, and transverse mandibular arch dimensional changes over a minimum of 30 weeks.66 consecutive patients allocated to treatment with a self-ligating bracket system (SmartClip) and conventional preadjusted edgewise brackets (Victory). Initial study models and cephalograms were obtained within a month of starting the trial. All subjects received treatment with the following arch wire sequence: 0.016-in round, 0.017 x 0.025-in rectangular, 0.019 x 0.025-in rectangular martensitic active nickel-titanium archwires,and 0.019 x 0.025-in stainless steel archwires. Final records, including study models and a lateral cephalogram, were collected a minimum of 30 weeks after initial appliance placement. Lateral cephalograms were assessed for treatment-related changes in mandibular incisor inclination and position. Transverse dimensional changes in intercanine, interpremolar, and intermolar dimensions, and the amount of crowding alleviated during the study period were assessed by comparison of pretreatment and posttreatment models. There was little difference overall in the pattern of arch alignment and leveling related to the 2 preadjusted appliances.

However, there was a statistically greater increase in intermolar width in the group treated with the self-ligating appliance, although the difference was only 0.91 mm.

Sayeh Ehsani, Marie-Alice Mandich (2009)[56] in their systematic review, compared the amount of frictional resistance between orthodontic self-ligating brackets and conventionally ligated brackets. Several electronic databases were searched without limits. In vitro studies that addressed friction of self-ligating brackets compared with conventionally ligated brackets were selected and reviewed. Compared with conventional brackets, self-ligating bracket produce lower friction when coupled with small round arch wires in the absence of tipping and torque in an Idealy aligned arch. There is no sufficient evidence to claim that with large rectangular wires, in the presence of tipping and torque and in arches with considerable malocclusion, self-ligating brackets produce lower friction compared with conventional brackets. Interactive bracket systems are passive for 0.014 and 0.016 inch wires and as the dimension of the wire increased the clip actively engage the wire into the slot and the frictional forces are increased.

Amy Archambault, Thomas. W. major (2010)[2] done this investigation to compare the torque expression between wire types. With a worm-gear–driven torquing apparatus, wire was torqued while a bracket mounted on a six-axis load cell was engaged. Three 0.019 x 0.025 inch wire (stainless steel, titanium molybdenum alloy [TMA], copper nickel titanium [CuNiTi]), and three 0.022 inch slot bracket combinations (Damon 3MX, In-Ovation-R, SPEED) were compared. Authors concluded that Stainless steel has the largest torque expression, followed by TMA and then NiTi.

Amy Archambault, Ryan Lacoursiere (2010)[1] evaluated the quantitative effects on torque expression of varying the slot size of stainless steel orthodontic brackets and the dimension of stainless steel wire, and to analyze the limitations of the experimental methods used. In vitro studies measuring torque expression in conventional and self-ligating stainless steel brackets with a torque-measuring device, with the use of straight stainless steel orthodontic wire without second-order mechanics and without loops, coils, or auxiliary wires, were sought through a systematic review process. Eleven articles were selected. Direct comparison of different studies was limited by differences in the measuring devices used and in the parameters measured. On the basis of the selected studies, in a 0.018 inch stainless steel bracket slot, the engagement angle ranges from 31 degrees with a 0.016 _ 0.016 inch stainless steel archwire to 4.6 degrees with a 0.018×0.025 inch stainless steel archwire. In a 0.022 inch stainless steel bracket slot, the engagement angle ranges from 18 degrees with a 0.018× 0.025 inch stainless steel archwire to 6° with a 0.021× 0.025 inch stainless steel archwire. Active stainless steel self-ligating brackets demonstrate an engagement angle of approximately 7.5 degrees, whereas passive stainless steel self-ligating brackets show an engagement angle of approximately 14° with 0.019× 0.025 inch stainless steel wire in a 0.022 inch slot. They concluded that engagement angle depends on archwire dimension and edge shape, as well as on bracket slot dimension, and is variable and larger than published theoretical values. Clinically effective torque can be achieved in a 0.022 inch bracket slot with archwire torsion of 15 to 31 degrees for active self-ligating brackets and of 23 to 35 degrees for passive self-ligating brackets with a 0.019 x 0.025 inch stainless steel wire.

Pandis. N and Argy polychronopoulou (2010)[43] compared the time required to complete the alignment of crowded maxillary anterior teeth (canine to canine) between Damon MX and In-Ovation R self-ligating brackets. The amount of crowding of the maxillary anterior dentition was assessed by using the irregularity index. The number of days required to completely alleviate the maxillary anterior crowding in the 2 groups was investigated. An analysis of each protocol was performed. Author concluded that there is no difference in crowding alleviation was found between In Ovation R and Damon MX bracket systems .

Stephanie Shih-Hsuan Chen,a Geoffrey Michael Greenlee (2010)[59] done this systematic review to identify and review the orthodontic literature with regard to the efficiency, effectiveness, and stability of treatment with self-ligating brackets compared with conventional brackets. Self-ligation appears to have a significant advantage with regard to chair time, based on several cross-sectional studies. Analyses also showed a small, but statistically significant, difference in mandibular incisor proclination. No other differences in treatment time and occlusal characteristics after treatment were found between the 2 systems that are supported by the current evidence. Retraction efficiency is not significantly efficientcompared to conventional. long-term studies are required with the greater sample size for better understanding the efficiency of self -ligating brackets .

Padhraig S. Fleminga; Ama Johalb (2010)[44] evaluated the clinical differences in relation to the use of self-ligating brackets in orthodontics. Six RCTs and 11 CCTs were identified from the electronic databases which investigated the influence of bracket type on alignment efficiency, subjective pain experience, bond failure rate, arch dimensional changes, rate of orthodontic space closure, periodontal outcomes, and root resorption were selected. Both authors were involved in validity assessment, and data extraction. Disagreements were resolved by discussion. Meta-analysis of the influence of bracket type on subjective pain experience failed to demonstrate a significant advantage for either type of appliance. Authors concluded it is difficult to assess the efficiency at this stage because there is insufficient high-quality evidence to support the use of self-ligating fixed orthodontic appliances over conventional bracket system.

Emily Ong and Hugh McCallum (2010)[15] compared the efficiency of self-ligating and conventionally ligated brackets during the first 20 weeks of extraction treatment. 50 consecutive patients who had premolar extractions in the maxillary and/or mandibular arch, 0.022 x 0.028-in slotbrackets , and similar archwire sequences were examined. Forty-four arches received Damon 3MX brackets , and 40 arches received either Victory Series or Mini -Diamond brackets. The models were evaluated for anterior arch alignment, extraction spaces, and arch dimensions at pretreatment (T0), 10 weeks (T1), and 20 weeks (T2). They concluded that there were no significant differences between the self- ligating and conventionaly ligated groups at 20 weeks in irregularity scores. There were no significant differences in passive extraction space closures between the groups.

Jack burrow. S (2010)[24] compared the rate of retraction of maxillary canine teeth when bracketed with a self-ligating bracket on one side and a conventional bracket on the other. 43 patients requiring maxillary premolar extraction was selected and a self-ligating bracket (Damon3, SmartClip) was used on the maxillary canine on one side and a conventional bracket (Victory Series) on the other. The teeth were retracted down a 0.018-inch stainless steel archwire, using a medium Sentalloy retraction spring (150 g). The mean movement per 28 days for the conventional bracket was 1.17 mm. For the Damon bracket it was 0.9 mm and for the SmartClip bracket it was 1.10 mm. The differences between the conventional and self-ligating brackets were statistically significant. Author concluded that the retraction rate is faster with the conventional bracket, probably because of the narrower bracket width of the self-ligating brackets lead to greater elastic binding and resistance to sliding is much more determined by this factor than by friction.

Voudouris J.C, Christos Schismenos (2010)[68] tested the frictional resistance forces generated between several archwires and (1) interactive self-ligating (ISL) brackets In-Ovation- C, In-Ovation-R, and Damon 3 ,and (2) conventionally ligated (CL) brackets Mystique with Neo Clip, Clarity, and Ovation. Frictional forces produced between three different archwire combinations and self-ligating (SL) brackets (ceramic and metal-slot or all-metal) and CL brackets (metal or ceramic) were evaluated in a dry environment. Each bracket was tested with 0.020” SS, 0.019x 0.025SS and 0.018x 0.018 coated SS. Authors found that In Ovation R and In Ovation C exhibited the lowest frictional forces irrespective of the bracket material and the wire size, and CL brackets exhibited consistently higher frictional forces.

Mauricio Mezomo,Eduardo S.de lima etal (2011)[36] measured space closure during the retraction of upper permanent canines with self-ligating bracket(smart clip) and conventional(Gemini) brackets. Fifteen patients who required maxillary canine retraction into first premolar extraction sites as part of their orthodontic treatment completed this study. In a random split-mouth design, the retraction of upper canines was performed using an elastomeric chain with 150 g of force. The evaluations were performed in dental casts (T0, initial; T1, 4 weeks; T2, 8 weeks; T3, 12 weeks). The amount of movement and the rotation of the canines as well as anchorage loss of the upper first molars were evaluated. They found that the canine rotation during space closure was higher with conventional bracket due to disengagement of the wire from the bracket slot distally, retraction needs to be stopped until canine rotation is corrected. Rotation of the upper canines during sliding mechanics was minimized with self-ligating brackets. Authors Concluded that distal movement of the upper canines and anchorage loss of the first molars were similar with both conventional and self-ligating brackets.

Thomas . W. Major, Jason. P. Carey (2011)[67] done this study to quantify torque expression in 3 self-ligation bracket systems (Damon Q, In-Ovation Rand Speed) during loading and unloading. A stepper motor was used to rotate a wire in a fixed bracket slot from –15degree to 63degree in 3degree increments, and then back to –15degree. The bracket was mounted on top of a load cell that measured forces and moments in all directions. Damon's and In-Ovation's maximum average torque values at 63° were 105 and 113 Nmm, respectively. Many Speed brackets experienced premature loss of torque between 48°and 63°, and the average maximum was 82 Nmm at 54°. The torque plays for Damon, In-Ovation, and Speed were 11.3°, 11.9°, and 10.8°, respectively. They conclude that, In-Ovation expressed the most torque at a given angle of twist, followed by Damon and then Speed. However, there was no significant difference between brackets below 34 Nmm of torque. From a clinical perspective, the torque plays between brackets were virtually indistinguishable.

MATERIALS AND METHODS

Twenty consecutive patients who met the selection criteria were included in the study in the Dept. of Orthodontics, Ragas Dental College & Hospital, Chennai. The inclusion criteria for all twenty patients were as follows.

1. Adolescent / younger adult in permanent dentition of either gender
2. All first bicuspid extraction
3. Class 1 molar relation
4. Group A anchorage
5. First and second molars to be banded or bonded in upper and lower jaw

Previous history of orthodontic treatment, any missing tooth other than third molar, root canal treated tooth or any temporomandibular dysfunction were excluded from the study.

Twenty patients were randomly divided into two groups of ten each: Group A and Group B.

Group A patients was bonded with conventional pre-adjusted edgewise, Roth 0.022 slot brackets (Ovation;Dentsply,GAC) Fig(2) and Group B patients was bonded with self-ligating pre-adjusted edgewise, Roth 0.022 slot brackets (In-Ovation-R; Dentsply, GAC) Fig(2). which were positioned with Boon's gauge, in both upper and lower arch. The first and second molars were banded with Roth prescription with weldable buccal tube and lingual sheath was used in the first molars for transpalatal arch

Leveling and aligning was done with 0.016-inch NiTi (Lancer orthodontics) in the upper arch and 0.014-inch or 0.016-inch NiTi in the lower arch depending on the crowding followed by 0.018inch SS (A.J. Wilcock special plus Australia.) and 19×25 NiTi (Lancer orthodontics) wire in both upper and lower arch. After alignment, preformed 19×25-inch SS double key-hole loop archwire (Truforce stainless steel, Ortho Technology USA) was placed passively for 4 weeks. Then 10^0 gable bend with reverse curve was placed bilaterally mesial to the second loop and the loop was activated by 1mm to produce a force of 150g/side and tied with Suzuki tie from the second molar hook to the second loop of the wire Fig (5). Reactivation was done once in four weeks after canine attains its mesial tip.

Lateral cephalograms and models were taken at the beginning of retraction (T1) and at the end of retraction (T2) Fig (6, 7, 8, 9). To differentiate the right and left sides on the lateral cephalogram, a jig was fabricated using 19×25-inch SS wire in ”Z” shape for the right side and “L” shape for the left side, ligated to the canine bracket and first molar buccal tube in both arches Fig(1). All lateral cephalograms were traced by the same investigator.

LAND MARKS AND REFERENCE PLANE[23,46]

NASION(N) – The most anterior point of the nasofrontal suture in the median plane.

SELLA(S)- The midpoint of the hypophysial fossa. It is a constructed point in the median plane.

GONION(GO)- A constructed point , the intersection of the lines tangent to the poaterior margin of the ascending ramus and the mandibular base.

MENTON(ME)- It is the most caudal point in the outline of the symphysis, it is regarded as the lowest point of the mandible and corresponds to the anthropological gnathion.

PTERYGOID VERTICAL(Pt.V): A vertical line drawn through the distal radiographic outline of the pterygomaxillary fissure and perpendicular to the Frankfort horizontal plane

ANTERIOR NASAL SPINE(ANS)- Is the tip of the bony anterior nasal spine, in the median plane.

POSTERIOR NASAL SPINE(PNS)- This is a constructed radiological point, the intersection of a continuation of the anterior wall of the pterygo palatine fossa and the floor of the nose. It marks the dorsal limit of the maxilla

INCISION INFERIUS APICALIS(Iia) – The root apex of the most anterior mandibular central incisor, if this point is needed only for defining the long axis of the tooth, the midpoint on the bisection of the apical root width can be used;

INCISION INFERIUS INCISALIS(Iii) – The incisal edge of the most prominent mandibular central incisor;

INCISION SUPERIUS APICALIS(Isa) – The root apex of the most anterior maxillary central incisor;

INCISION SUPERIUS INCISALIS(Isi) – The incisal edge of the most anterior maxillary central incisor.

S-N PLANE: It is the cranial line between the center of sella tursica (sella) and the anterior point of the anterior point of the fronto-nasal suture (nasion). It represents the anterior cranial base.(Steiner's analysis)

FRANKFORT HORIZONTAL PLANE: It is the line connecting porion and orbitale. (McNamara analysis)

PALATAL PLANE: It is a line connecting the anterior nasal spine of the maxilla and the posterior nasal spine of the palatine bone**.**

MANDIBULAR PLANE (Go-Me):. A line connecting gonion and menton (Downs analysis).

MAXILLARY MEASUREMENT

In the maxilla the linear measurements was taken from pterygoid vertical along the Frank fort horizontal plane.[31] The horizontal distance from pterygoid vertical to the jig on the molar and canine was used to assess anchorage loss and en-masse anterior retraction on both sides Fig (10, 11).

The change in incisor inclination was measured along the long axis of the incisor to the palatal plane. To assess molar angulation a line is drawn passing through the furcation area bisecting the crown to the palatal plane Fig (10,11).

MANDIBULAR MEASUREMENTS

In the mandible the linear measurements were taken from sella vertical along the SN plane.[7] The horizontal distance from the sella vertical to the jig on the molar and canine was used to assess anchorage loss and en-masse retraction on both sides Fig (10,11).

The change in incisor inclination was measured along the long axis of the incisor to the mandibular plane. To assess molar angulation a line is drawn passing through the furcation area bisecting the crown to the mandibular plane Fig (10, 11).

Ricketts superimposition was done to demonstrate pre and post retraction changes in terms of molar anchor loss, net anterior retraction, molar angulation and anterior torque loss.

STATISTICAL ANALYSIS:

All statistical analysis was performed by using SPSS software package (SPSS for Windows XP, version 16.o, Chicago). For each variable measured on the lateral cephalogram, the mean and standard deviation were calculated.

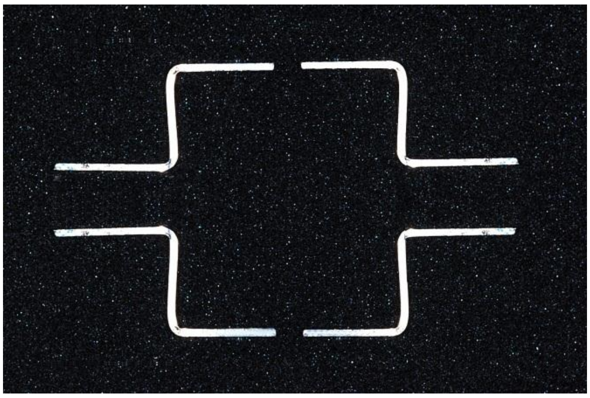
Independent T Test was done to compare the molar anchor loss, amount of anterior retraction, torque loss and total retraction time at T1(before retraction) and T2 (end of retraction) between Conventional (Group A) and Self-ligation (Group B) brackets.

Mann Whitney U Test was done to evaluate the change in molar angulation at T1 (before retraction) and T2 (end of retraction) between Conventional (Group A) and Self-ligation (Group B) brackets.

P < 0.05 was considered statistically significant

Figure (1) JIG USED FOR MEASUREMENT

Right side



Left side

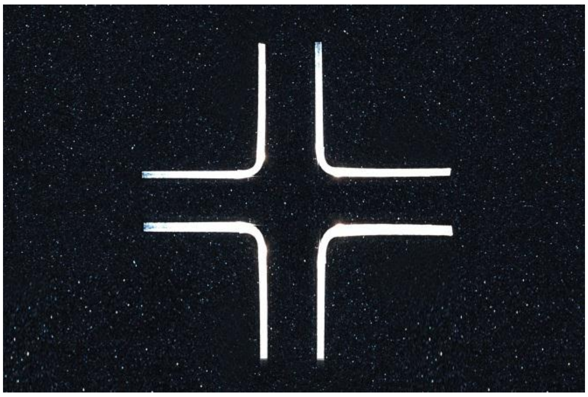


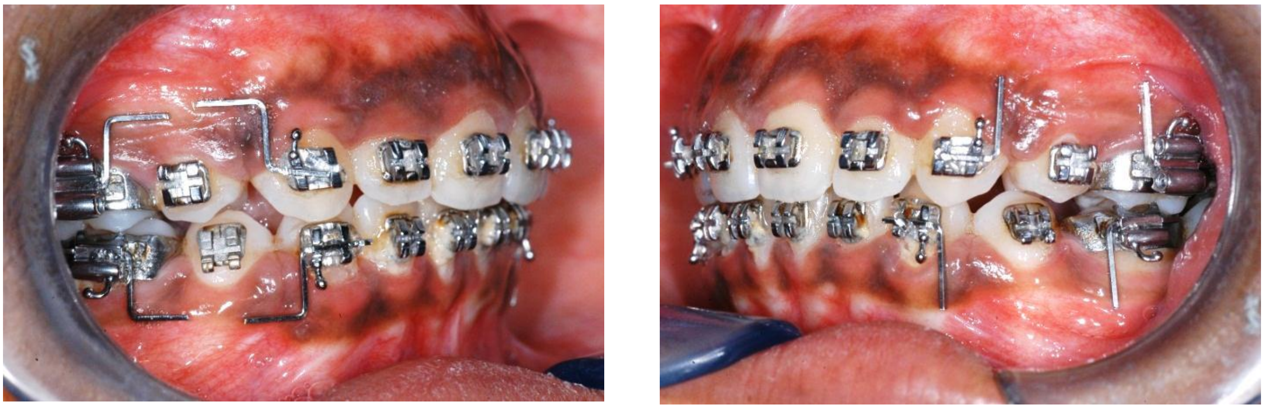
Figure (2) BRACKETS USED IN THE STUDY

In-Ovation-R Bracket Kit.

Ovation bracket Kit.

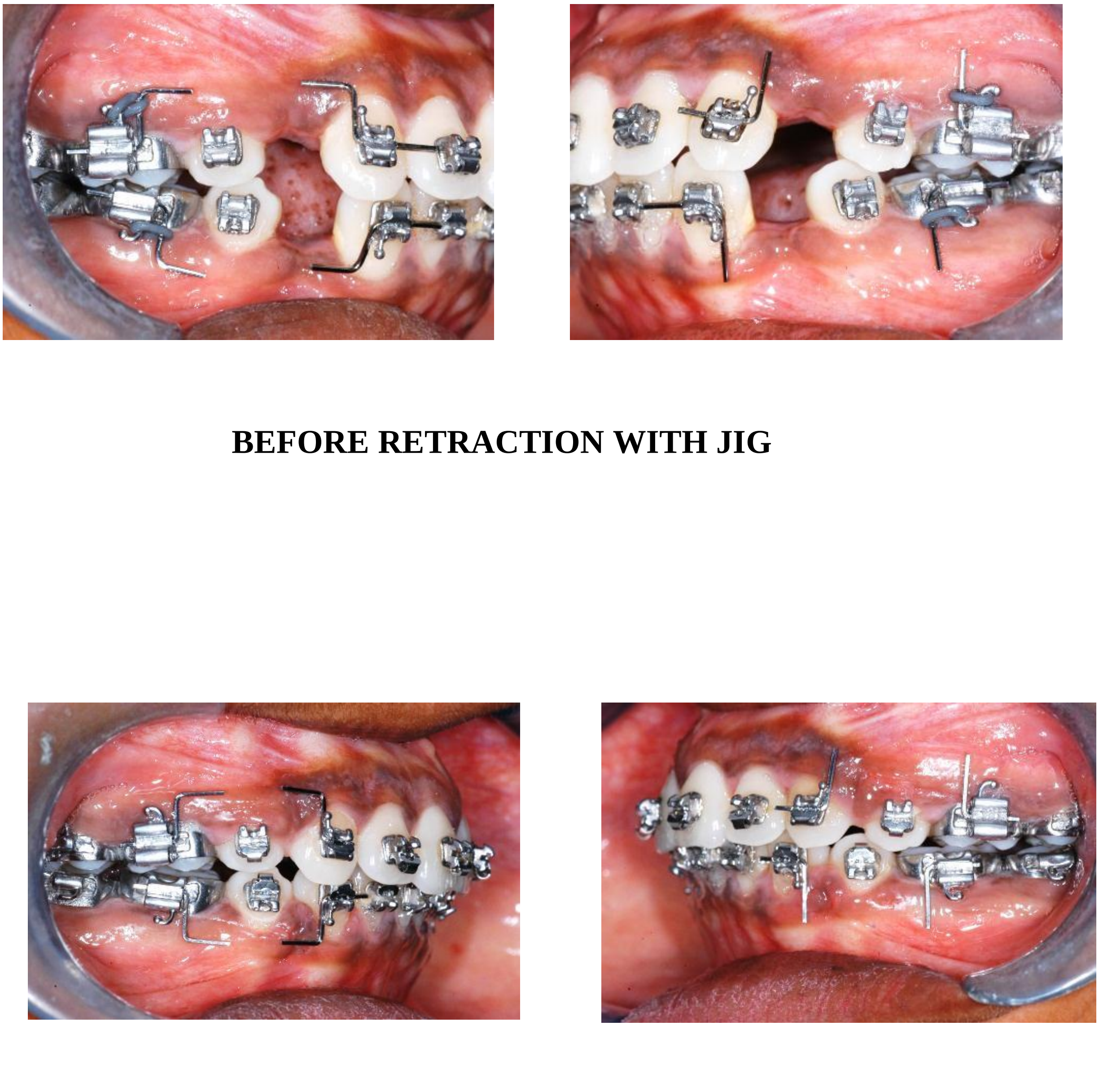
Figure (3). CASE OF CONVENTIONAL BRACKET SYSTEM

BEFORE RETRACTION WITH JIG



AFTER RETRACTION WITH JIG

Figure (4). CASE OF SELF-LIGATING BRACKET SYSTEM

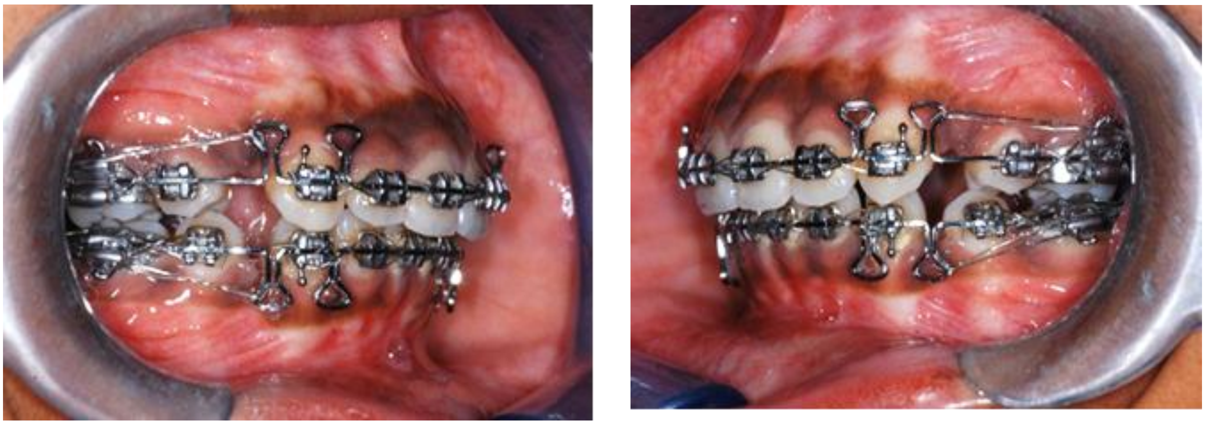


BEFORE RETRACTION WITH JIG

AFTER RETRACTION WITH JIG

Figure (5). RETRACTION WITH SUZUKI TIE

GROUP A (CONVENTIONAL BRACKET)



GROUP B (SELF-LIGATING BRACKET)

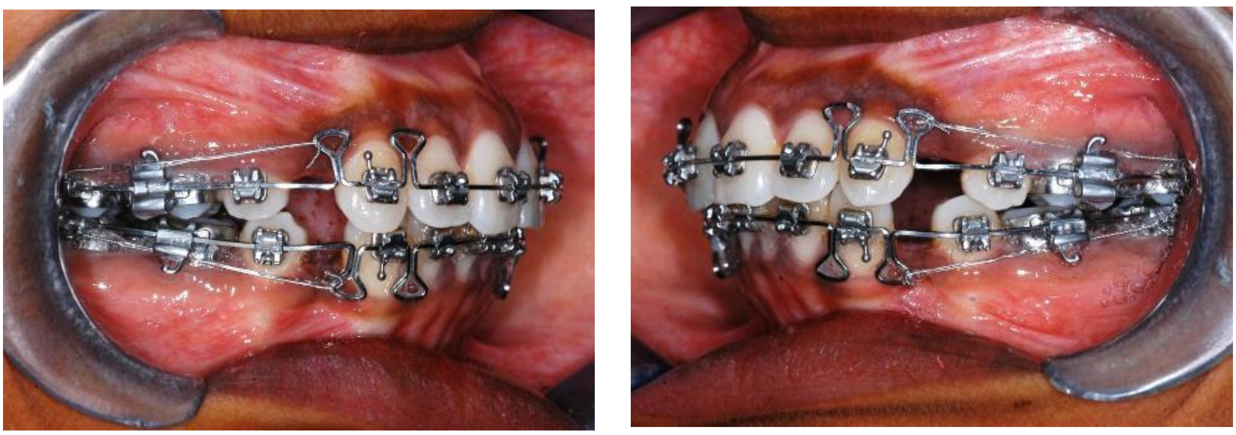


Figure (6). Before Retraction with Jig: Group A (Conventional Bracket)

Figure (7). After Retraction with Jig: Group A (Conventional Bracket)

Figure (8). Before Retraction with Jig: Group B (Self-Ligating Bracket)

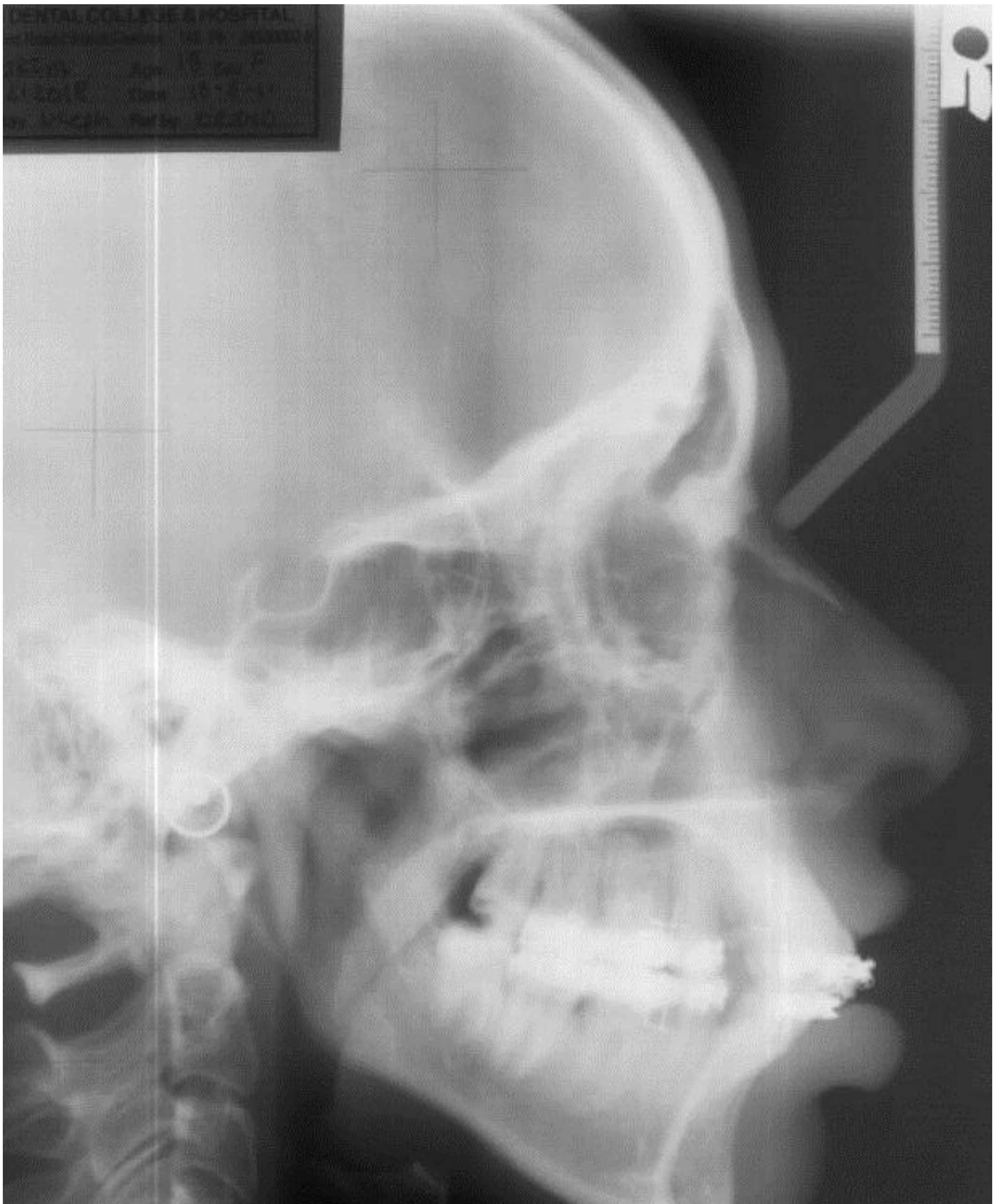


Figure (9). After Retraction with Jig: Group B (Self-Ligating Bracket)

REFERENCE PLANES USED IN CEPHALOMETRIC ASSESSMENT

S-N PLANE: It is the line connecting sella and the nasion points.

FRANKFORT HORIZONTAL PLANE: It is the line connecting porion and orbitale points.

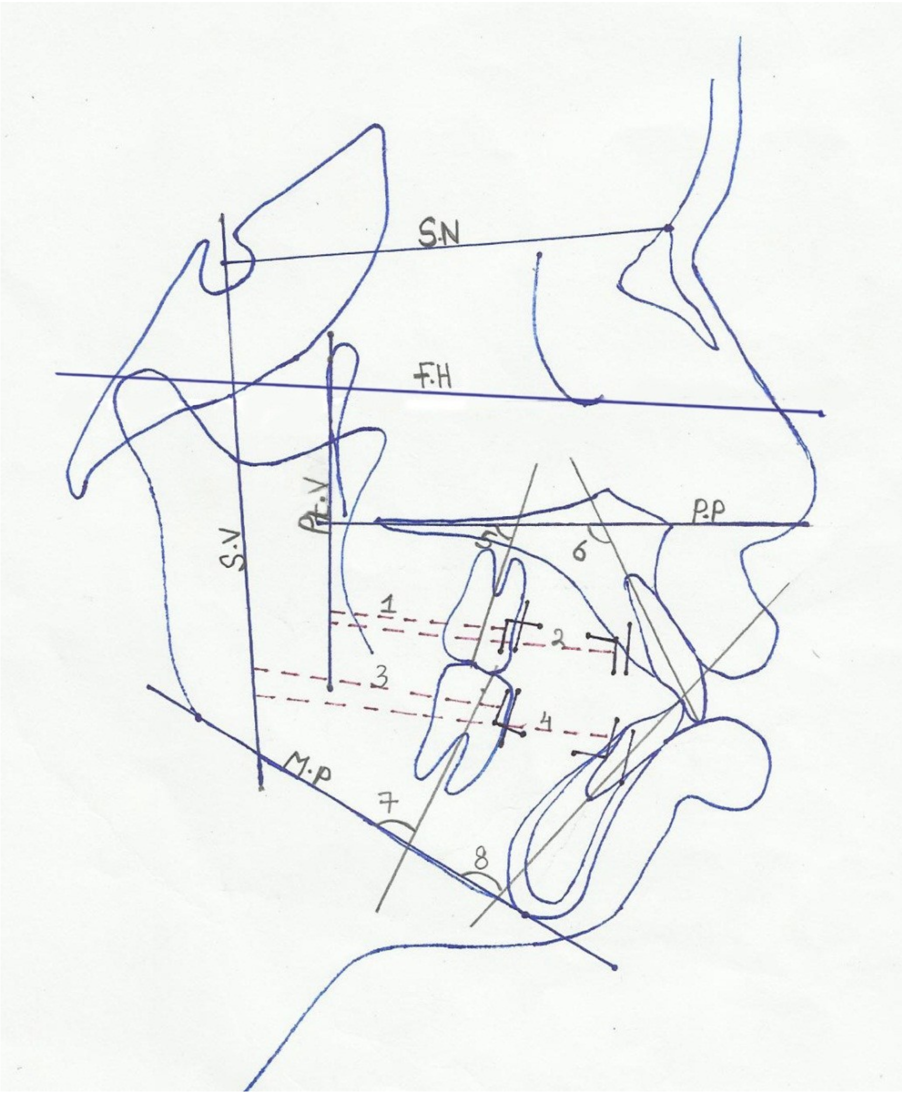
PALATAL PLANE: It is a line connecting the anterior nasal spine of the maxilla and the posterior nasal spine of the palatine bone**.**

MANDIBULAR PLANE (Go-Me):. A line connecting gonion and menton points.

SELLA VERTICAL(S.V): It is a vertical line drawn perpendicular to SN plane at sella point.

PTERYGOID VERTICAL(Pt.V): It is a vertical line drawn perpendicular to Frankfort horizontal plane at Ptv point.

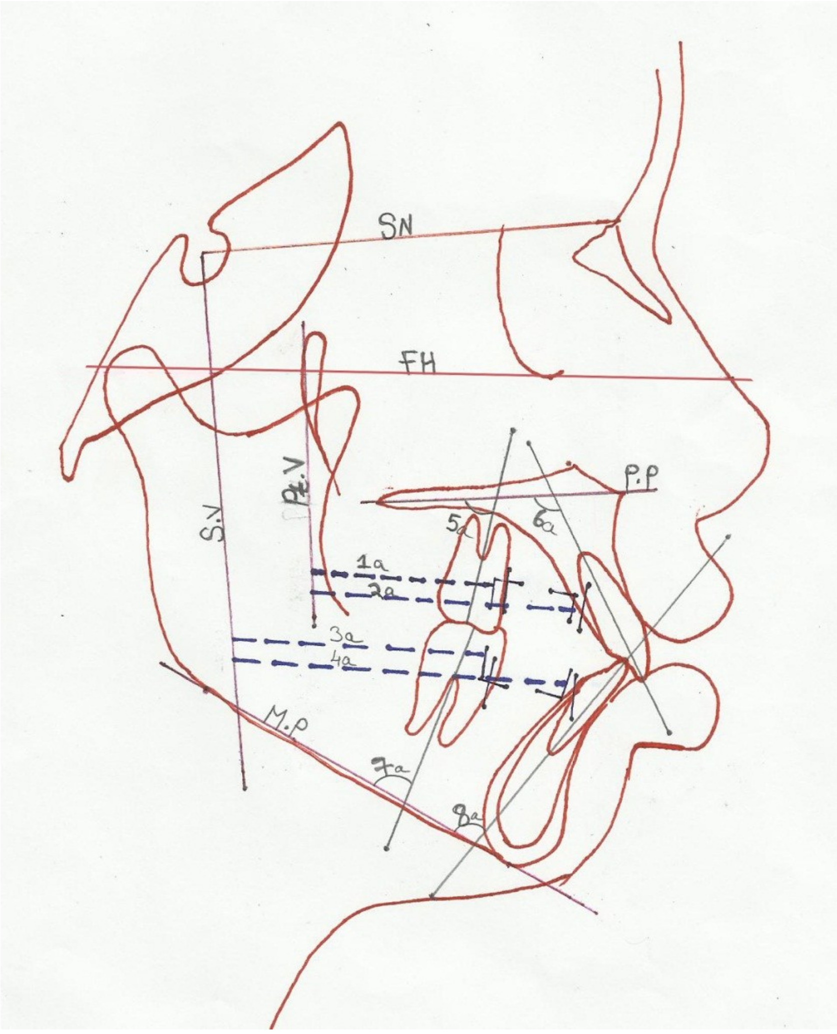
Figure (10). Cephalometric Measurements- Before Retraction



MEASURMENTS:

- ❖ 1. Horizontal distance from Pterygoid Vertical to Maxillary Molar Jig
- ❖ 2. Horizontal distance from Pterygoid Vertical to Maxillary Canine Jig.
- ❖ 3. Horizontal distance from Sella Vertical to Mandibular Molar Jig.
- ❖ 4. Horizontal distance from Sella Vertical to Mandibular Canine Jig.
- ❖ 5. Maxillary Molar Angulation to Palatal Plane.
- ❖ 6. Maxillary Incisor Angulation to Palatal Plane.
- ❖ 7. Mandibular Molar Angulation to Mandibular Plane
- ❖ 8. Mandibular Incisor Angulation to Mandibular Plane

Figure (11). After Retraction- Cephalometric Tracing.

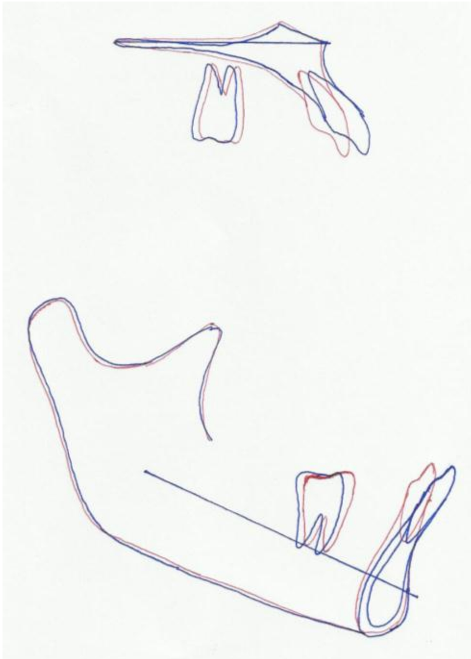


MEASURMENTS:

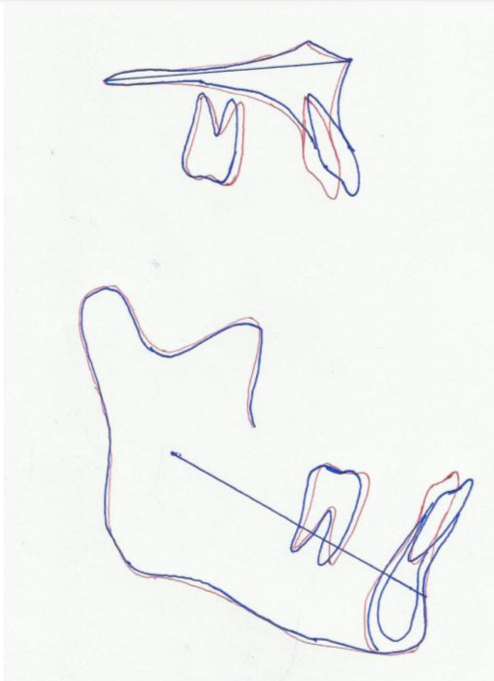
- 1(a)Horizontal distance from Pterygoid Vertical to Maxillary Molar Jig
- 2(a) Horizontal distance from Pterygoid Vertical to Maxillary Canine Jig.
- 3(a) Horizontal distance from Sella Vertical to Mandibular Molar Jig.
- 4(a) Horizontal distance from Sella Vertical to Mandibular Canine Jig.
- 5(a) Maxillary Molar Angulation to Palatal Plane.
- 6(a) Maxillary Incisor Angulation to Palatal Plane.
- 7(a) Mandibular Molar Angulation to Mandibular Plane
- 8(a) Mandibular Incisor Angulation to Mandibular Plane

Figure 12

Superimposition: Group A (Conventional Bracket)



Superimposition: Group B (Self-Ligating Bracket)



RESULTS

This study comprised of 20 patients divided into two groups, Group A and Group B, of 10 patients each. The mean age of the patient were16 years ±3.2 years in both the groups.

The results are discussed under the following headings:

Molar Anchorage Loss in Group A between right and left sides: Table 1a

Molar anchor loss within group A is tabulated in Table 1a. Results showed there was no statistically significant difference in molar anchor loss between right and left side in both the arches.

Molar Anchorage Loss in Group B between right and left sides: Table 1a

Molar anchor loss within group B is tabulated in Table 1a. Results showed there was no statistically significant difference in molar anchor loss between right and left side in both the arches.

Comparison of Molar Anchorage Loss between Group A and Group B: Table 1b

Comparison between Conventional and Self-ligating groups for molar anchorage loss is tabulated in Table 1b. Results showed there was no statistically significant difference in molar anchor loss in maxillary and mandibular arches.

Amount of Anterior Retraction in group A between right and left sides: Table 2a

Amount of anterior retraction within group A is tabulated in Table 2a. Results showed there was no statistically significant difference in anterior retraction between right and left side in both the arches.

Amount of Anterior Retraction in group B between right and left sides: Table 2a

Amount of anterior retraction within group B is tabulated in Table 2a. Results showed there was no statistically significant difference in anterior retraction between right and left side in both the arches.

Comparison of Amount of Anterior Retraction between Group A and Group B: Table 2b.

Comparison between Conventional and Self-ligating brackets groups for amount of anterior retraction is tabulated in Table 2b. Results showed there was no statistically significant difference in amount of anterior retraction in maxillary and mandibular arch.

Comparison of Torque Loss between Group A and Group B: Table 3.

Comparison of torque loss between Conventional and Self-Ligating groups is tabulated in Table3. Results showed there was no statistically significant difference in torque loss in maxillary and mandibular arch

Comparison of Molar Angulation between Group A and Group B: Table 4.

Comparison of degree of molar tipping between Conventional and Self-Ligating groups is tabulated in Table 4. In maxillary and mandibular arches results showed there was no statistically significant difference in molar angulation.

Total Retraction Time between Group A and Group B: Table 5.

Total retraction time is tabulated in Table 5.There is a statistically significant difference in total retraction duration with self-ligating brackets compared to conventional brackets.

Table 1a: Molar Anchorage Loss in the Same Group

Group	N	Mean	Std. Deviation	Std. error mean	P value	Significance
Group A maxillary arch						NS
Right	10	1.8000	0.25820	0.08165	0.449	
left	10	1.9000	0.31623	0.10000		
Group A mandibular arch						NS
Right	10	1.9000	0.31623	0.10000	0.749	
left	10	1.9500	0.36893	0.11667		
Group B maxillary arch						NS
Right	10	1.8500	0.24152	0.07638	0.628	
left	10	1.9000	0.21082	0.06667		
Group B mandibular arch						NS
Right	10	1.8500	0.24152	0.07638	0.660	
left	10	1.8000	0.25820	0.08165		

NS: Not significant;

*p < 0.05 (statistically significant);

**p < 0.001 (statistically highly significant)

Table 1b: Molar Anchorage Loss between Two Groups

Group A vs Group B	N	Mean	Std. Deviation	Std. error mean	P value	Significance
Group A maxillary arch	10	1.8000	0.25820	0.08165	0.660	NS
Group B maxillary arch	10	1.8500	0.24152	0.07638		
Group A mandibular arch	10	1.9000	0.31623	0.10000	0.696	NS
Group B mandibular arch	10	1.8500	0.24152	0.07638		

NS: Not significant;

*p < 0.05 (statistically significant);

**p < 0.001 (statistically highly significant)

Table 2a: Amount of Anterior En-Masse Retraction in the Same Group

Group	N	Mean	Std. Deviation	Std. error mean	P value	Significance
Group A maxillary arch						NS
Right	10	3.1000	0.31623	0.10000	1..000	
left	10	3.1000	0.31623	0.10000		
Group A mandibular arch						NS
Right	10	2.8000	0.25820	0.08165	0.062	
left	10	3.1000	0.39441	0.12472		
Group B maxillary arch						NS
Right	10	2.9500	0.36893	0.11667	0.169	
left	10	3.1500	0.24152	0.07638		
Group B mandibular arch						NS
Right	10	3.0500	0.36893	0.11667	0.482	
left	10	3.1500	0.24152	0.07638		

NS: Not significant;

*p < 0.05 (statistically significant);

**p < 0.001 (statistically highly significant)

Table 2b: Amount of Anterior En-Masse Retraction between Two Groups

Group A vs Group B	N	Mean	Std. Deviation	Std. error mean	P value	Significance
Group A maxillary arch	10	3.1000	0.31623	0.10000	0.342	NS
Group B maxillary arch	10	2.9500	0.36893	0.11667		
Group A mandibular arch	10	2.8000	0.25820	0.08165	0.096	NS
Group B mandibular arch	10	3.0500	0.36893	0.11667		

NS: Not significant;

*p < 0.05 (statistically significant);

**p < 0.001 (statistically highly significant)

Table 3 Incisor Inclination (Torque Loss) between Two Groups

Group A vs Group B	N	Mean	Std. Deviation	Std. error mean	P value	Significance
Group A maxillary arch Group B maxillary arch	10 10	5.70 6.10	1.059 0.738	0.335 0.233	0.340	NS
Group A mandibular arch Group B mandibular arch	10 10	5.90 6.30	0.738 0.675	0.233 0.675	0.222	NS

NS: Not significant;

*p < 0.05 (statistically significant);

**p < 0.001 (statistically highly significant)

Table 4: Molar Angulation (Tipping) between Two Groups

Test	Maxillary molar tipping	Mandibular molar tipping
Mann-Whitney u	43.500	47.500
Wilcoxon W	98.500	102.500
P value	0.516	0.845
significance	NS	NS

NS: Not significant;

*p < 0.05 (statistically significant);

**p < 0.001 (statistically highly significant)

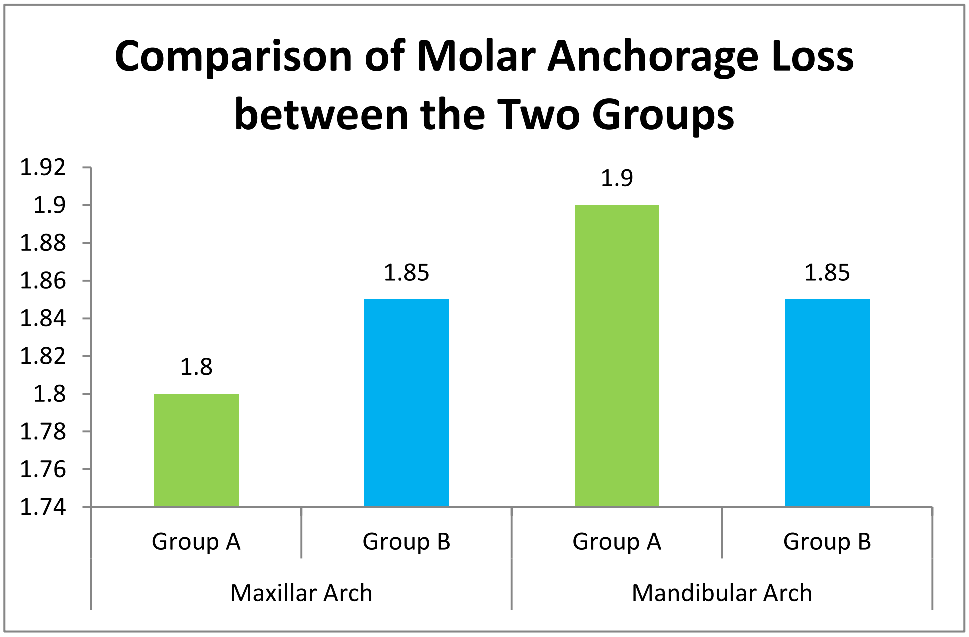
Table 5 Comparison of Total Retraction Time between Two Groups

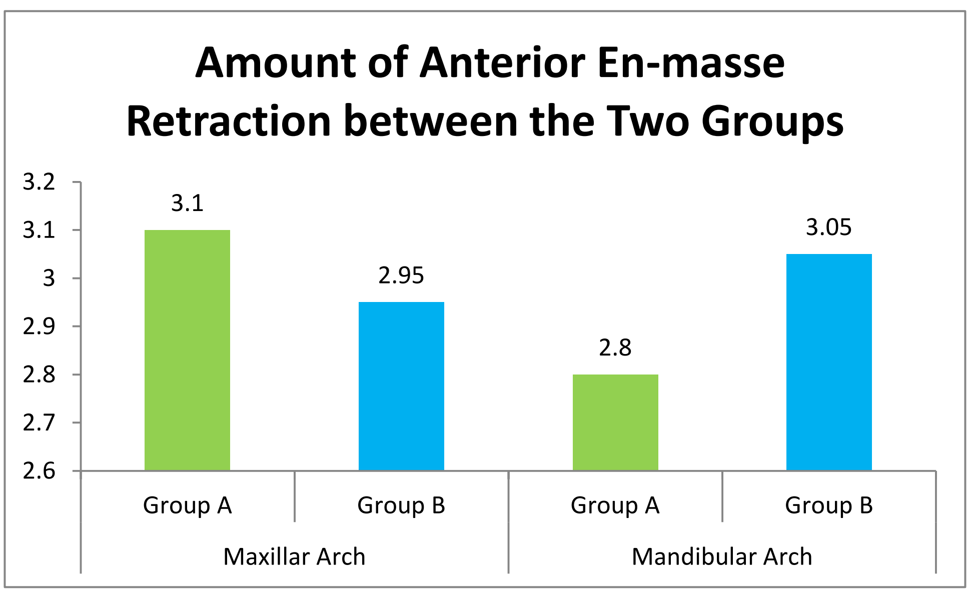
Group A vs Group B	N	Mean	Std. Deviation	Std. error mean	P value	Significance
Group A	10	10.0300	0.70871	0.22411	0.000	**(highly significant)
Group B	10	7.1560	0.46448	0.14688		

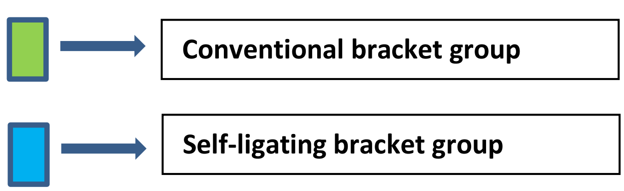
NS: Not significant;

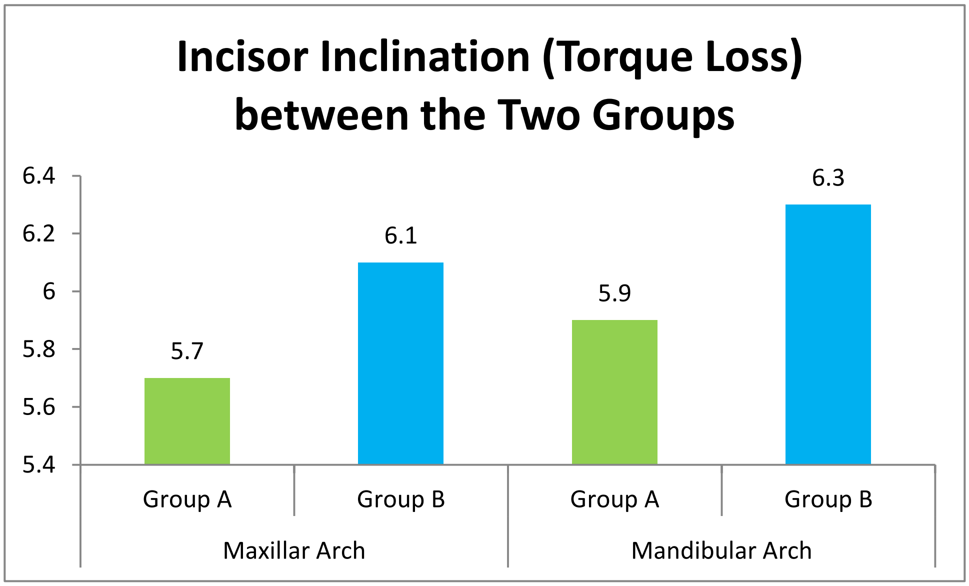
*p < 0.05 (statistically significant);

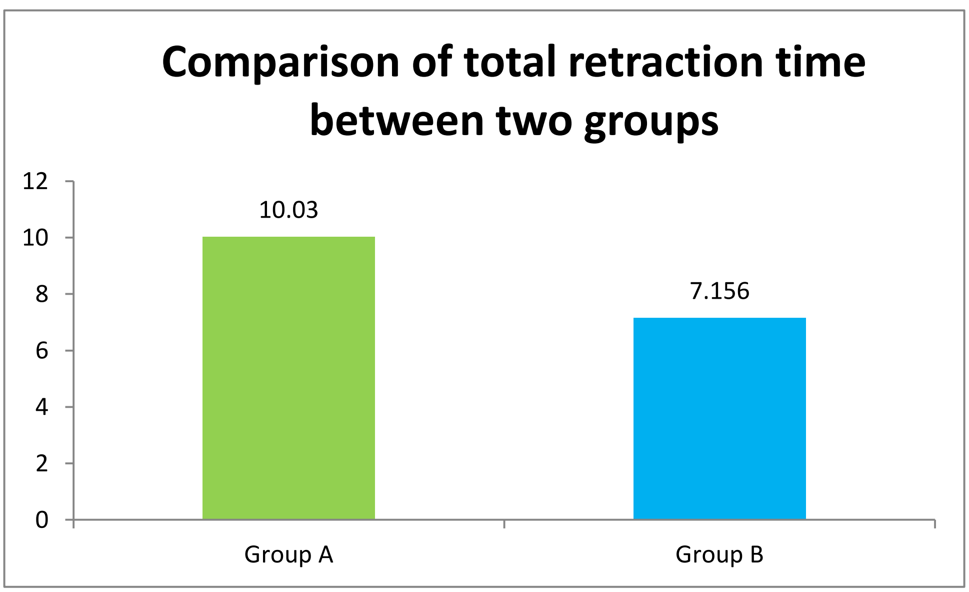
**p < 0.001 (statistically highly significant)


Comparison of Molar Anchorage Loss between the Two Groups
1.92
1.9
1.88
1.86
1.84
1.82
1.8
1.78
1.76
1.74
1.8
1.85
1.9
1.85
Group A
Group B
Group A
Group B
Maxillar Arch
Mandibular Arch


Amount of Anterior En-masse Retraction between the Two Groups
3.2
3.1
3
2.9
2.8
2.7
2.6
3.1
2.95
2.8
3.05
Group A
Group B
Group A
Group B
Maxillar Arch
Mandibular Arch


Conventional bracket group
Self-ligating bracket group





Conventional bracket group

Self-ligating bracket group

DISCUSSION

The ability to close extraction spaces preferentially is an essential skill required during orthodontic treatment. Space closure is usually done in one step (en-masse) or two step (individual canine retraction), either with friction mechanics or frictionless mechanics. One of the major factors which affect the treatment efficiency is the ligation system and friction that is increased by elastomeric module, elastomeric chain and stainless steel ligature because of the stress they exert on the wire adjacent to the bracket sides. Thereby, precluding free sliding of the wire into the slot walls and adversely affecting rate of tooth movement.[39]

Interest in self-ligating brackets has grown in recent years. Several in-vitro studies have demonstrated a substantial decrease in the coefficient of friction of self-ligating brackets, a possible clinical advantage over conventional brackets, especially for sliding mechanics.[20]

Literature is scant with reference to treatment efficiency of interactive self-ligating brackets during en-masse space closure. Prospective clinical trials by **Peter G Miles**[35] have found no significant difference in the rate of space closure between passive self-ligating brackets and conventional twin brackets. **Mauricio Mezomo**[36] evaluated the distal movement of canine and molar anchor loss between passive self-ligating bracket and conventional bracket and found no significant difference between the two bracket systems. **Jack Burrow**[24] compared the canine retraction rate of self-ligating brackets with conventional bracket system and found a faster retraction with conventional bracket, probably due to the narrower bracket width of self-ligating brackets. However, one of the drawbacks of passive self-ligating bracket is lack of 3-dimensional control of teeth during retraction.[55]

To the best of our knowledge, there has been no study that has evaluated the retraction efficiency of interactive self-ligating brackets.

The present study used the interactive self-ligating bracket system with the passive-active clip system. This refers to the fact that round wires less than 0.020 inches in diameter sit passively in the slot, with no force being delivered from the clip. Any wire with a bucco-lingual dimension larger than 0.020 inches will receive a greater amount of force from the actively displaced cobalt-chromium clip, thereby delivering rotational and torque control.[55] Studies done by **Henao et al**[19] found that the bracket is passive for 0.014 and 0.016 inch wires and as the dimension of the wire increased the clip actively engaged the wire into the slot**.** This is because the horizontal gingival wall is reduced and therefore the dimension is reduced to 0.0195 inch width and not 0.028 inch. In this regard, the interactive bracket systems have better 3-dimensional control compared to passive self-ligation system. However, it is believed that Passive self-ligating brackets produced less frictional force compared to active self–ligating brackets.[55]

Therefore, to reduce friction with interactive brackets, loop mechanics was chosen for the present study. To our knowledge there has been no study in the literature that has evaluated the retraction efficiency of double key-hole loop. **Roth**[47] stated that double key-hole loop has better rotational control of canines during retraction and the entire extraction space could be closed with one set of arch wires.

Thus, the present study was done to compare the en-masse retraction efficiency of interactive self-ligating bracket (In ovation R Dentsply GAC) and conventional bracket (Ovation Dentsply GAC) with double key-hole loop. A 19×25 inch stainless steel preformed double key-hole with gable bend and reverse curve was used for better torque control during retraction. The loop was activated one millimeter per month.[8] According to Roth double key-hole loop can be activated by stretching and cinching the arch wire distal to the second molar activating one millimeter per month.

Suzuki Tie[49]: It is a method of activation using ligature wire extending from second molar hook to the second loop of double key hole, thereby producing activation of 1 mm per month. The problem of cinching the arch wire is difficulty in purchasing the wire distal to second molar in some patients and difficulty in removing the arch wire, if needed midway during retraction. Therefore, in the present study, Suzuki tie was given for all patients for activating the double key-hole loop.

The treatment efficiency is discussed under the following headings:-

- Anchorage loss and Molar Tipping
- Amount of Anterior Retraction and Torque loss.
- Total Retraction Time.

Anchorage loss and Molar Tipping:

Tweed[60,61] emphasized anchorage preparation as the first step in orthodontic treatment. Anchorage is generally classified into Group A, Group B and Group C.[50] In the present study, Group A anchorage was used because all subjects included in the study were Class 1 bimaxillary protrusion cases requiring maximum retraction of anterior teeth. Anchorage preparation was done by tying a passive transpalatal arch in the first molars[21] and the second molars banded.

The present study used a side identification jig designed “Z” shape for the right side and long “L” shaped for the left side Figure (1) in both the arches. The advantage of this modification is that the jigs were clearly visible on the lateral cephalogram without being obstructed by molar and canine hooks, thereby making side identification easier to locate and superimpose compared to the jigs as used in other similar studies.[3,5] Lateral cephalograms were taken at T1 (before retraction) and at T2 (end of retraction). All cephalograms were traced manually by the operator. For maxillary arch, the horizontal distance from pterygoid vertical to first molar jigs was taken on both sides as suggested by **McNamara**[31] method. Likewise for mandibular arch, the horizontal distance from sella vertical to first molar jigs was taken on both sides according to **Bjork**[7] method. The molar tipping was assessed by drawing a line bisecting the first molar crown passing through the furcation area to the palatal plane for maxilla and to the mandibular plane for mandible. The difference in the pre-treatment and post-treatment retraction values evaluated the net anchorage loss and molar angulation. There was no statistically significant difference between the right and left sides within the same group, because preformed double key hole loop was used with uniform height and width and activation of one mm per month was done bilaterally symmetrical. Comparison between conventional and self-ligating group also showed no statistically significant difference in molar anchorage loss and molar tipping. It would therefore appear that although the molar anchor loss was slightly lesser in self-ligating group it did not make a significant difference clinically.

This could be probably because of the same retraction mechanics (double key-hole loop) used in both the groups.

Amount of Anterior Retraction and Torque Loss:

One of the popular methods of space closure to conserve treatment time is en-masse retraction. **Wook Heo**[70] found no significant difference in molar anchor loss and anterior retraction with en-masse or two step retraction except for the treatment time that was prolonged in a two-step retraction method.

The present study evaluated the amount of anterior retraction by measuring the horizontal distance from pterygoid vertical to canine jigs on both sides for maxilla and horizontal distance from sella vertical to canine jigs on both sides for the mandible. Torque loss was calculated by change in incisor inclination before and after retraction. Results showed no significant difference between conventional and self-ligating group for anterior retraction and torque loss. **Thomas W. Major**[67] in an in-vitro study evaluated the torque expression of In-Ovation R self-ligating bracket with 0.019 x 0.025 inch stainless steel arch wire and found a torque loss or slop of 11.9°. Similarly, **Mc Laughlin, Bennet and Trevisi**[32] have postulated a slop of 10° with conventional brackets. The present study also showed similar changes with both conventional and self-ligating brackets. However, **Badawi et al**[4] measured the torque expression of two active and two passive self-ligation brackets from 0° to 57° with increasing angles, results showed that active self-ligating system was more effective in torque expression than passive self-ligating system. Since the study was done in vitro it cannot be directly matched in a clinical scenario.

Total Retraction Time:

One of the claims of self-ligating bracket system is reduced treatment time.[20] However, previous studies have not found any significant difference in overall treatment duration between conventional and self- ligation bracket systems.[59] Therefore, the type of movement and ligation mechanism does not seem to affect the duration of treatment.

In the present study the retraction rate was faster with interactive self-ligating brackets compared to conventional brackets**.** There are very few literature studies evaluating the efficacy of self-ligating brackets during en-masse space closure. The result of the present study is in contrast to other studies. **Thorstenson and Kusy**[62] demonstrated that in-vitro; the resistance to sliding of self-ligating brackets was lower than those of conventional brackets in the absence of ligation force. However, **Peter.G.Miles**[35] in his prospective clinical trial demonstrated no significant difference between conventional and passive self-ligating group with sliding mechanics. Therefore, in the present study double key-hole loop was used for retraction in both the groups to eliminate friction. A possible explanation for faster retraction rate with self-ligating brackets could be due to combination of low friction brackets with frictionless mechanics which maximally reduced the frictional forces.

The present study evaluated the efficiency of self-ligation and conventional brackets only in sagittal plane. Arch width changes and vertical changes have not been addressed. Other possible confounding variables could include the bone density, bone turnover rate and age of the patient. Moreover, it is postulated that light continuous forces produces 1.8 times greater tooth movement compared to light dissipating or heavy forces.[69]

Therefore, further studies with more sample size are needed to investigate the force delivery of interactive self-ligating brackets compared to conventional brackets and their effect on overall treatment efficiency.

CONCLUSION

The following conclusions can be made from the present study.

1. There was no difference in the quantum of molar anchorage loss between conventional brackets and self-ligating brackets in both the arches.
2. No difference in the quantum of anterior retraction between conventional brackets and self-ligating brackets in both the arches was observed.
3. Conventional and self-ligating brackets were no different in the amount of anterior torque expression and molar tipping in both the arches.
4. However there was perceivable difference in total retraction time with self-ligating brackets being faster compared to the conventional brackets.

Therefore, both the bracket systems are equally efficient during en-masse retraction with loop mechanics.

BIBLIOGRAPHY

1. **Amy Archambault, Ryan Lacoursiere-** Torque expression in stainless steel orthodontic brackets. A Syestematic Review. Angle Orthod. 2010;80:201-210.
2. **Amy Archambault**; **Thomas.w. Major-** A comparison of torque expression between stainless steel, titanium molybdenum, and copper nickel titanium wires in metallic self-ligating brackets. Angle orthod 2010;80:884-889.
3. **Badri.Thiruvenkatachari , A. Pavithranand –** Comparison and measurement of the amount of anchorage loss of the molars with and without the use of implant anchorage during canine retraction. Am J Orthod Dentofacial Orthop 2006;129:551-4
4. **Badawi**.**H.M, Toogood. R.W**- Torque expression of self-ligating brackets. Am J Orthod Dentofacial Orthop . 2008; 133:721-728.
5. **Badri.Thiruvenkatachari, A. Pavithranand-** Comparison of rate of canine retraction with conventional molar anchorage and titanium implant anchorage. Am J Orthod Dentofacial Orthop 2008;134:30-5
6. **Begg.PR. -**Differential force in orthodontic treatment. Am J Orthod. 1956,42:481-510.
7. **Bjork.A-** Prediction of mandibular growth rotation. Am J Orthod. 1969;75:39-53.
8. **Burstone.C.J and Herbert .A. Keenig-** Optimizing anterior and canine retraction- Am J Orthod. 1976; 70: 1-19
9. **Burstone.C.J** Anchorage control and the extraction patient. Orthodontics for the Next Millenium. Glendora, Calif: Ormco; 2001:293.

10. **Cordasco G, Farronato G, Festa F, Nucera R, Grossi GB-** In vitro evaluation of the frictional forces between brackets and archwire with three passive self-ligating brackets-Eur J Orthod. 2009 Dec;31(6):643-6.

11. **Damon DH-** The rationale, evolution and clinical application of the self-ligating bracket. Clin Orthod Res. 1998; 1: 52–61.

12. **Darryl V Smith , P.Emile Rossouw, Phillip Watsonab** Quantified simulation of canine retraction: evaluation of frictional resistance-Sem in orthodontics2003; Volume 9, Issue 4, Pages 262-280.

13. **Daniel J. Rinchusea and peter .G. Miles**- Self-ligating brackets: present and future. Am J Orthod Dentofacial Orthop 2007;132:216-22

14. **Edward Mah, Michael Bagby, Peter Ngan, Mark Durkee**- Investigation of frictional resistance on orthodontic brackets when subjected to variable moments. Am J Orthod Dent- Orthop 2003 Jan;100.

15. **Emily Ong, Hugh McCallum-**Efficiency of self-ligating vs conventionally ligated brackets during initial alignment. Am J Orthod Dentofacial Orthop 2010;138:138.e1-138.e7.

16. **G. E. Readward-** A Comparison of Self-ligating and Conventional Orthodontic bracket systems –Br journal of Orthodontics.1997;Vol. 24:309–317

17. **Hain M , Dhopatkar A , Rock P-** The effect of ligation method on friction in sliding mechanics . Am J Orthod Dentofacial Orthop -2003 123: 416 – 422.

18. **Harradine N.W.T.** – Current Products and Practices Self-ligating brackets: where are we now? Journal of Orthodontics, Vol. 30, 2003, 262–273

19. **Henao S.P, Kusy RP**- Frictional evaluations of dental typodont modelsusing four self-ligating designs and a conventional design. Angle orthod 2005;75(1):75-85.

20. **Harradine N. W. T.** – The history and development of self-ligating brackets. Semin orthod 2008;14:5-18.

21. **Heather .L. Zablockl, McNamara. A. James**- Effects of the transpalatal arch during extraction treatment. Am J Orthod Dentofacial Orthop. 2008;133:852-60.

22. **Jacob. Stolzenberg-** The Russell attachment and its improved advantages. Int J Orthor Dent children.1935; vol 21,issue 9,page 837-840.

23. **Jacoboson .** A. Caufield.W.Page- Tracing technique and identification of land mark- Radiographic cephalometry, from basics to videoimaging. 1995;53-62.

24. **Jack Burrow. S-** Canine retraction rate with self-ligating brackets vs conventional edgewise brackets. Angle Orthod. 2010;80:626-633.

25. **Kapur R, Sinha PK, Nanda RS-** Frictional resistance of the Damon SL bracket- Journal of Clinical Orthodontics 1998; 32:485-489.

26. **Kemp DW-** A Comparative Analysis of Frictional Forces between Self-ligating and Conventional Edgewise Orthodontic Brackets; Department of Orthodontics,University of Toronto; 1992.

27. **Krishnan M, Kalathil S, Abraham KM-** Comparative evaluation of frictional forces in active and passive self-ligating brackets with various archwire alloys – Am J Orthod Dentofacial Orthop. 2009 Nov; 136(5): 675-82.

28. **Kusy, Whitley** -Influence of archwire and bracket dimensions on sliding mechanics: derivations and determinations of the critical contact angles for binding. Eur J Orthod. 1999;21:199–208

29. **Kuhlberg.J.K, Priebe.N.D-** space closure and anchorage control. Sem in Orthod 2001;7:42-49.

30. **Luca Pizzoni-** Frictional forces related to self-ligating brackets; European Journal of Orthodontics 1998;20: 283–291.

31. **McNamara**. **J.A-** A method of cephalometric evaluation. Am J Orthod 1984;86:449-69.

32. **McLaughlin.P.R, Bennet .C.J, Trevisi** .J.H. Systemized orthodontic treatment mechanics. 2001;16-17.

33. **Moore .M.M, E.Harrington-** Factors affecting friction in the pre-adjusted appliance. Eur J Orthod. 2004;579-583.

34. **Miles.P.G and Weyant. R.J-** A clinical trial of Damon 2 vs conventional twin brackets during initial alignment. Angle Orthod. 2006;76:480-485

35. **Miles. P.G –** Self-ligating vs conventional twin brackets during en-masse space closure with sliding mechanics. Am J Orthod Dentofacial Orthop 2007;132:223-5.

36. **Mauricio Mezomo,Eduardo S.de lima-** Maxillary canine retraction with self-ligating and conventional brackets. Angle Orthod. 2011;81:292–297.

37. **Profit WR, and Fields HW -** Contemporary orthodontics.3rd ed. St Louis: Mo: CV Mosby;2000:348.

38. **Pandis . N, strigou .S-** Maxillary incisor torque with conventional and passive self-ligating brackets: a prospective clinical trial. Orthod Craniofacial Res 9, 2006:193-198

39. **Pandis.N, Argy polychronopoulou**- Self-ligating vs conventional brackets in the treatment of mandibular crowding: A prospective clinical trial of treatment duration and dental effects. Am J Orthod Dentofacial Orthop 2007;132:208-15.

40. **Paul Scott, Andrew T. Dibiase-** Alignment efficiency of Damon 3 self-ligating and conventional orthodontic bracket systems: A randomized clinical trial. Am J Orthod Dentofacial Orthop 2008;134:470.e1-470.e8).

41. **Padhraig S.Fleming, Andrew. T. DiBiase-** comparison of mandibular arch changes during alignment and levelling with 2 preadjusted edgewise appliance. Am J Orthod Dentofacial Orthop 2009;136:340-7.

42. **Padhraig S.Fleming, Andrew. T. DiBiase-** Efficiency of mandibular arch alignment with 2 preadjusted edgewise appliance. Am J Orthod Dentofacial Orthop 2009;135:597-602

43. **Pandis.N, Argy polychronopoulou-** Active or passive self-ligating brackets? A randomized controlled trial of comparative efficiency in resolving maxillary anterior crowding in adolescents. Am J Orthod Dentofacial Orthop 2010;137: 12-13.

44. **Padhraig S. Fleming, Ama Johal-** Self-ligating brackets in orthodontics. A Systematic Review. Angle Orthod. 2010;80:575-584.

45. **Priscilla. Denny-** Retrospective cephalometric investigation of the effects of soldered transpalatal arches on the maxillary first molars during orthodontic treatment involving extraction of maxillary first bicuspids. Am J Orthod Dentofacial Orthop 2006;129(1):81-82.

46. **Rakosi Thomas –** The introduction of cephalometry to orthodontics. An Atlas and Manual of cephalometric radiography. 1982;41-42.

47. **Roth. H. Ronald, Graber and Swain-** Treatment mechanics for straight wire appliance. Orthodontic current principles and technique. First indian edition 1991; 688-690.

48. **Roth. H.Ronald, Grabber and vanarssall-** Treatment mechanics for straight wire appliance. Orthodontic current principles and technique. Second edition; 1994:685-711

49. **Roth. H. Ronald-** Suzuki tie and its activation pattern. Roth mannual

50. **Ravindra nanda-** Biomechanics of space closure. Biomechanics and Esthetic Strategies in Clinical Orthodontics. 2004;194-196.

51. **Staggers. A. j. Germane. N-** Clinical consideration in the use of retraction mechanics. Jou clin orthod. 1991;364-369.

52. **Storey. E and Smith.R-** Force in orthodontics and its relation to tooth movement . Aust J Dent. 1952;56:13.

53. **Susan Thomas, Martyn sherriff and david birnie.** A comparative in vitro study of the frictional characteristics of two types of self-ligating brackets and two type of pre-adjusted edgewise brackets tied with elastomeric ligatures. Eur J Orthod. 1998;589-596.

54. **Silvia.G, Shpack.Nir-** Anchorage loss- a multifactorial response. Angle orthod 2003;73:730-737.

55. **Steven Budd, John Daskalogiannakis-** A study of the frictional characteristics of four commercially avaialable self-ligating bracket systems. Eur J Orthod. 2008; 645-653.

56. **Sayeh Ehsani, Marie-Alice Mandich-** Frictional resistance in self ligating orthodontic brackets and conventionally ligated brackets. A Syestematic Review. Angle Orthod. 2009;79:592-601.

57. **Shivapuja PK, Berger J-.** A comparative study of conventional ligation and self-ligating bracket systems. Am J Orthod Dentofacial Orthop 1994;106:472-480.

58. **Simona Tecco-** Friction of conventional and self-ligating brackets using a 10 bracket model- Angle orthod 2005;75:1041-1045.

59. **Stephanie Shih-Hsuan Chen, Geoffrey Michael greenlee-** Systematic review of self ligating brackets. Am J Orthod Dentofacial Orthop 2010;137:726.e1-726.e18.

60. **Tweed .C.H-** A philosophy of orthodontic treatment. Am J Orthod Oral surgery. 1943;31:74-103.

61. **Tweed.C.H-** Clinical Orthodontics. St Louis, MO: CV Mosby;1966.

62. **Thostenson G.A, kusy**- Resistance to sliding of self-ligating brackets versus conventional stainless steel twin brackets with second-order angulation in the dry and wet (saliva) states. Am J Orthod Dentofacial Orthop 2001;120:361-370.

63. **Thorstenson.G.A, RP Kusy-** Effect of archwire size and material on the resistance to sliding of self-ligating brackets with second order angulations in the dry state; Am J Orthod Orthop 2002;122:295-305

64. **Turnbull.N.R , David J. Birnie-** Treatment efficiency of conventional vs self-ligating brackets: effects of archwire size and material. Am J Orthod Dentofacial Orthop 2007;131:395-99.

65. **Tae-kyung kim, ki-Dal Kim-** comparison of frictional forces during initial levelling stage in various combinations of self-ligating brackets and archwires with a custom-designed typodont system. Am J Orthod Dentofacial Orthop 2008;133:187.e15-187.e24

66. **Tselepis M, Brockhurst P, West VC-** The dynamic frictional resistance between orthodontic brackets and arch wires- Am J Orthod Dentofacial Orthop.1994;106(2):131-8

67. **Thomas .w. major, Jason.P.Carey**- Mechanical effects of third-order movement in self- ligated brackets by the measurement of torque expression. Am J Orthod Dentofacial Orthop . 2011;139:e31-e44.

68. **Voudouris .J.C., Christos Schismenos(2010)-** Self- ligation esthetic brackets with low frictional resistance Angle Orthod. 2010;80:188-194.

69. **Warita.H. et al :** A study on experimental tooth movement with NiTi alloy orthodontic wires: comparison between light continuous force and light dissipating force. 1996;55:515-527

70. **Wook Heo, Dong Seok Nahm-** En-masse retraction and two step retraction of maxillary anterior teeth in adult class 1 women. Angle Orthod. 2007;77:973-978.